

# **EXPERT SYSTEMS FOR MANAGEMENT TRAINING IN THE CONSTRUCTION INDUSTRY**

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# **ABSTRACT**

The construction industry is based on age old skills where 'man' has been the builder and is coupled to his creative ability and skilled craftsmanship. This significant dependency on human resources continues to this day and thus the success of the construction industry is linked to making effective use of the human resources through training programmes. The research presented in this thesis investigates the use of expert systems in such management training programmes.

The work described in this thesis includes a literature survey in chapter 2 on different aspects of human resources management with particular emphasis on management training and learning styles. Chapter 3 presents the results and analysis of the civil engineering and management practices survey, which was carried out during this research. The survey focused mainly on management training and attitude towards computer technology within the construction industry. Expert systems as a branch of artificial intelligence is discussed in chapter 4, where an assessment of the usefulness of using expert systems in different areas of construction management is carried out. Research methodology and techniques of knowledge acquisition applied in this research are presented in chapter 5. The process of the different stages in the development of the contract and safety management expert system is presented in chapter 6, which further describes the structure in which the system was designed.

Finally, in order to assess the usefulness of the expert system tool developed, a summative evaluation is carried out. This evaluation examines many factors including attitudes towards computing, human-computer interaction, knowledge base

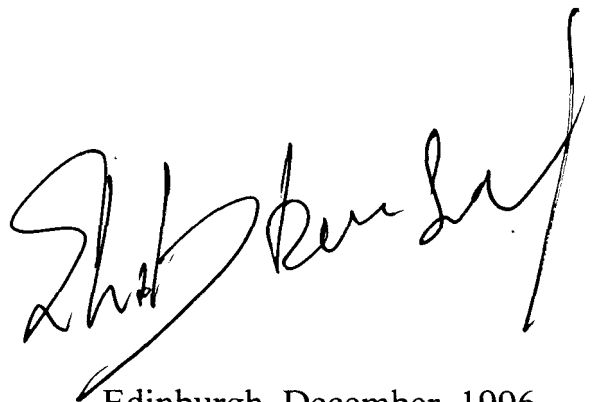
design, use of expert system for training and expert system evaluation tests. Evaluation results and analysis are presented in chapter 7.

It is concluded that there is certainty about the importance of management training in the construction industry. Developing expert systems for such training can be used as an aid tool in many training programmes. The choice of the development tool is considered to be an important function in this research in order to achieve the anticipated results by utilising the available resources. Evaluation of different shells was carried out against the criteria mentioned in chapter 4 and CRYSTAL 4.5 was chosen as the tool to be used in this research. During the development of the expert system, CRYSTAL 4.5 proved to be flexible and fast in structuring the knowledge base. The research also revealed the importance of the evaluation as an essential element of any systematic training program. Results obtained from the contract and safety management expert system evaluation (70% in favour of using expert systems for training) suggested that most trainees managed to grasp the subject information. Only a minority of trainees experienced difficulties during the training program. Those trainees will benefit from the implementation of the points which are raised in chapter 7.

# DECLARATION

This thesis is the result of research work undertaken in the Department of Civil and Environmental Engineering at the University of Edinburgh for the degree of Doctor of Philosophy.

I declare that all the work in this thesis has been carried out by myself unless otherwise stated, **and** the thesis has been composed by myself under the supervision of Dr. D. A. Ponniah and Mr T. W. Gore.



Edinburgh, December, 1996.

Ehab A. Ben Saoud

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**DEDICATED**

*to*

*My Father and Mother*

## **PUBLISHED PAPERS**

The following papers were published by the author in collaboration with my supervisors during the course of this thesis:

"Computing and the Construction industry". Structural Survey, Volume 12, Number 4, PP.10-14, 1994, (appendix H).

"A window on management training within the construction industry". Structural Survey, Volume 29, Number 4 & 5, PP.148-152, 1997, (appendix H).

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# **Chapter 1      Introduction**

## **1.1 Introduction**

The construction industry of Great Britain is unique, it is a large and highly diverse sector of industrial activity. It has literally built Britain, and its monuments are around for all to see. The construction industry is one of the few industries able to produce goods that increase in value over time. Unlike the majority of other products that begin to depreciate immediately from the time of purchase. In addition to providing investment, it offers a wide range of employment to all strata of society.

For many years there has been concern that the construction industry is not making full use of managing its human resources. In a survey carried out by the Construction Industry Training Board (1988), in relation to the management training needs within the construction industry, it was found that management skills were lacking and if quality and a better level of productivity was to be achieved much more training was required. The benefits of this would be significant in an industry dependent to a great extent on its labour force.

Hughes (1990), argued that there has been some recognition of these shortcomings in training but evidence suggests that little training took place in the past, in comparison to some other industrialised countries. This was confirmed by a number of surveys who collectively had a considerable impact on the consciousness of the construction industry (Coopers, 1985; Industrial Society, 1985; Mangham and Silver, 1986; Handy, 1987; Constable and McCormic, 1987). This added to an increasing awareness of the importance of change and the key role which training had played in helping that process.

Encouragingly, recent surveys in the early 1990s (Brewster and Hegewisch, 1993) reveal that companies seem to be taking training more seriously. The Price Waterhouse Cranfield Project Survey indicated that training and staff development is the leading issue for most personnel departments across Europe. including the UK.

This growing awareness of the importance of training over the past period is also supported by reports that employers are spending more in aggregate terms on training activities (Training Agency, 1989). Ryan (1991), however explained that the measurement of training expenditure is still very much a controversial issue and figures which do exist are very much open to question, interpretation and political manipulation. Other commentators share the view of Professor Richard Layard who states that: "The tragic reality is despite all the rhetoric about new initiative, real expenditure in off-the-job vocational education and training has if anything fallen over the past five years" (Williams. 1993).

Bass (1966) has defined training as a systematic modification of behaviour through learning which occurs as a result of education, instruction development and planned experience. Learning has been further defined by Nadler (1983) as a relatively permanent change in behaviour that occurs as a result of practice or experience. Training encompasses any attempt to improve current or future employee performance by increasing through learning an employee's ability to perform. This can take place usually by increasing the employee's skills and knowledge to remove deficiencies that cause employees to perform at less than the desired level in any organisation. Training enables employees to be much more productive, to reduce the learning time for employees starting in new jobs, displacements or promotions, and ensures that they become fully competent as quickly and economically as possible.

Bently (1991) suggested that the main role of training and development is ensuring that the organisation has the people with the correct mix of attributes to provide appropriate learning opportunities. motivating people to learn. and enabling them to perform at the highest level of quality and service.

Bently (1991), suggested further that the particular objectives of training are:

- ( i ) To develop the competence of employees and improve their performance;
- ( ii ) To help people grow within the organisation in order that human resource plans can be met within the organisation.

The construction industry is striving to improve the training and development of its management and labour force. Changing technologies, increased competition and the requirements of a well trained labour pool have spurred this need. It has also been recognised that with training and development comes higher productivity, higher profit, improved quality, lower operating cost, more reliable estimates, greater problem solving ability, more productive teams and better internal and external communication skills. Further there is the increasing realisation that a skilled labour force is the construction industry's most precious resource and the skills of all construction workers, be they managers, designers or others, need continuous up grading and updating (Imbert, 1991).

This is what is known today as human resource development. Such development is not only essential for successful construction management but also has effects which reach far beyond the construction industry and influences economic planning policy, making technological progress and the provision and distribution of resources required for construction.

Very large companies are often self sufficient in training resources. They tend to provide a range of standard courses for the lower levels of management and to put all their managers through these at appropriate times. These courses are always in house and usually given by their own employees with occasional use of specialist external consultants. Senior managers are treated more selectively and training is provided according to their need.

Medium sized companies provide a certain amount of management training on a more ad-hoc basis and less frequently. They use a mixture of in house courses usually put on by specialist consultants and external courses. Small companies do virtually no formal management training preferring either to develop management skills by gradually increasing the level of responsibility or recruit managers with appropriate skills as the need arises (Ireland, 1990).

Some of the training problems are associated with releasing people for training. Most companies prefer the short duration courses. They do not consider it is feasible to run courses at the week-end to avoid conflict with the normal working week, except for senior management whose commitment is generally greater.

Most companies prefer in house training courses specially tailored to their own needs and many of the companies who provide training choose to work with consultants in developing custom-built courses rather than send people on external courses.

In recent years the construction industry has begun to exploit advances in computer related technology. Companies have been making use of systems based training. Such systems involve the creation of four main elements. These are a comprehensive context sensitive help system, training information, and tutorials, simulations and

exercises that make use of the working system. The training team has to work closely with the systems development group. The work in such systems will involve advice on screen design, the writing of all the messages that will be accessed by users (this will replace the need for users manuals and guides) and the production of initial learning information. The information from the monitoring system will be used to give people an idea of how well they are performing with suggestions for more training or alternative working methods.

### **1.1 Aims of this thesis**

With the attempt to examine the different aspects of training management in the context of human resource management the aims of this thesis are therefore defined as:

( i ) To identify the concept of training management in human resource development with special reference to construction management training and to conduct a survey to this effect;

( ii ) To investigate expert systems application in construction management and the review of different systems shells that would be appropriate for building training expert systems;

( iii ) To introduce an expert system as an effective tool to manage construction management training;

( iv ) To develop a management training model using an expert system shell.

( v ) To investigate the viability of such a model to be fully developed and then implemented in the real life situation.

The work presented in this thesis has been carried out to meet the above aims.

## **1.2 The outline of the thesis**

The main text of the thesis consists of eight chapters. While this chapter is intended to give a brief introduction to the research background and the thesis, the remaining seven chapters can be presented as follows :

Chapter 2 gives a comprehensive review of the major theories and research work which provide the knowledge basis and theoretical background to management training and the use of computational training in this field;

Chapter 3 illustrates the results and analysis of the survey which has been carried out as part of this research to give the author an understanding of the current situation in management training and the attitudes to computer technology within the construction industry;

Chapter 4 gives a comprehensive review of the literature in expert systems and its applications in the construction industry;

Chapter 5 examines the methodology that is employed in this present research, explaining how the research was conducted from start to finish;



Chapter 6 describes the different stages of building the construction management expert system;

Chapter 7 reviews the methods for the evaluation of the expert system, and presents the analysis and discussion of the expert system evaluation which was carried out in this research;

In the last chapter of the thesis, chapter 8, the research findings are concluded and discussed. Topics for future research are also recommended.

The main text of this thesis is followed by the appendices which present the sample questionnaire that was used in the survey in chapter 3, the evaluation tables and results and the expert system evaluation questionnaire tables of results. Finally the appendices will contain a copy of the contract and safety management expert system that was developed in this research.

## **Chapter 2    Management Training and Development**

### **2.1 Introduction**

This chapter reviews the concepts and theories of human resource development, paying special attention to management training which is relevant to the research work presented in the thesis. Recent developments in human resource management and management training are reviewed, and the background to the present research is discussed.

### **2.2 The concept of training and development**

Training can be defined as an organised process concerned with the acquisition of capability or the maintenance of existing capability. Training in industry has a specific purpose, it should provide experience which develops the behaviour of employees in the areas of skills, knowledge and attitude ( Hamblin, 1974). Langford and Newcombe (1992) stated that education and training should be clearly defined and not to be confused with the management development functions within the organisation. The Manpower Services (1981) Commission, which was set up by the 1973 Employment and Training Act until it was replaced in 1988, defined training as: "A planned process to modify attitude, knowledge or skill behaviour through learning experience to achieve effective performance in an activity or range of activities. Its purpose, in the work situation, is to develop the abilities of the individual and to satisfy the current and future needs of the organisation".

The process of planned training, as shown in Figure 2.1 consists of the following steps (Armstrong, 1991) :

( i ) Identify needs - the analysis covers problems to be solved as well as future demands. Two points are usually considered at this stage, the best and most cost-effective way to meet those training needs.

( ii ) Define learning requirements - it would be important at this stage to examine the skills and knowledge level that is required to be developed in order to meet the new objectives identified by the training needs.

( iii ) Planning training programmes - Training techniques and locations of training should be considered at this stage. They must also be designed to meet training needs and objectives and learning requirements.

( iv ) Techniques, facilities, locations and trainers - These factors are based on the training programmes being developed to meet the needs and objectives by using the correct combination of training techniques and locations. A decision as to who provides the training, from within or outside the organisation, has to be made on the availability of suitable training, and the source of responsibility, i.e. training department or manager.

( v ) Implement the training - effective training methods must then be applied in order to allow trainees to gain the required skills, knowledge, and attitudes they need.

( vi ) Evaluate training - this step is considered to be of vital importance where trainee performances are monitored in order to find out if training objectives have

been met. Also this step provides feedback in producing any improvement which could enhance the effectiveness of training.

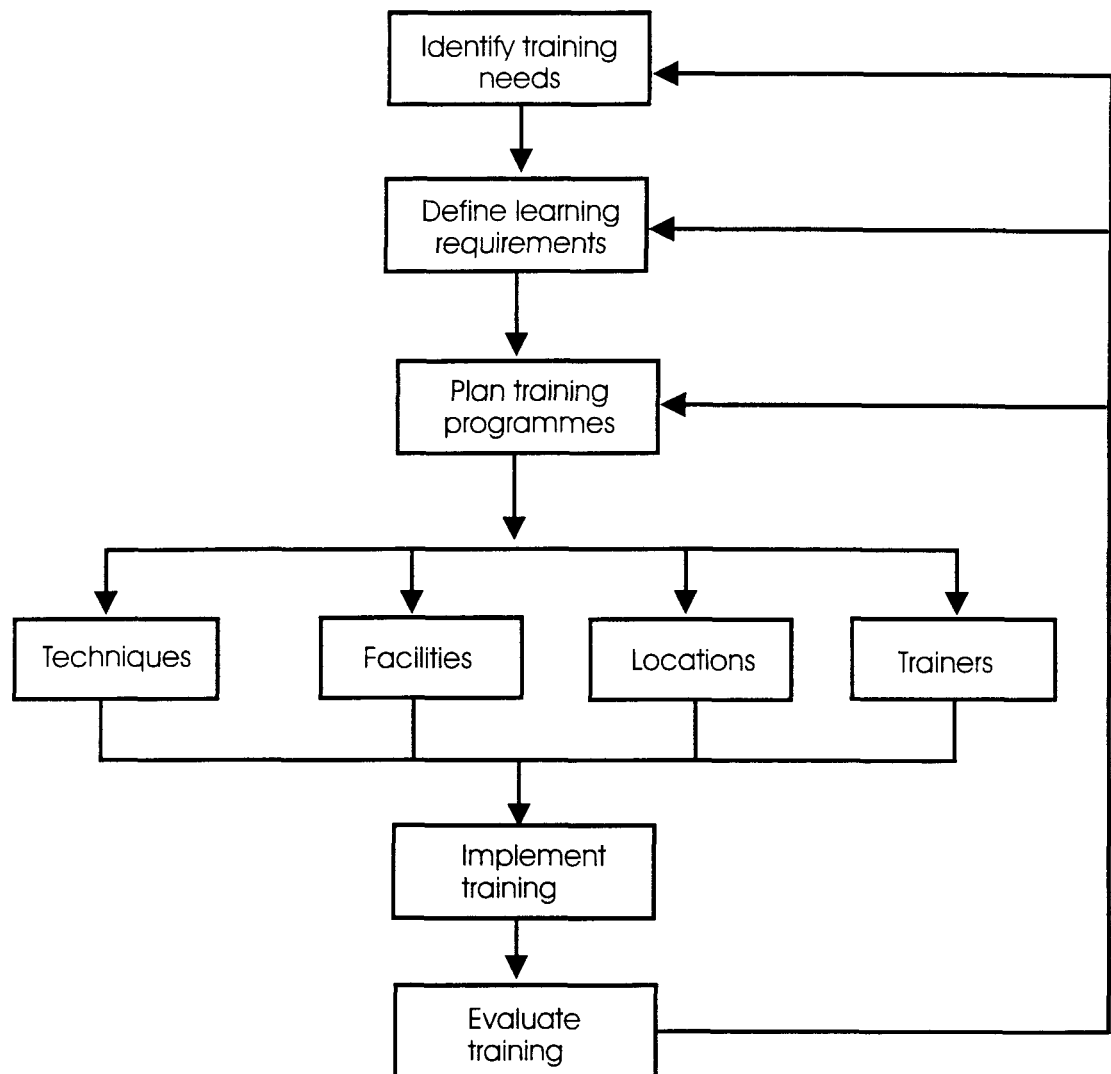


Figure 2.1 The process of planned training

Source: M. Armstrong, "Personal management practice", 1991

### 2.3 Personnel management

Many writers have argued that people are the organisation's most important asset, particularly in an intensive labour industry like the construction industry. The effective use of such a company resource, whether on a building site or in a designer's office, depends on the motives, abilities, and attitudes of people. Fryer

(1990) pointed out that good managers have for a long time recognised the importance of staff development, but it required legislation to make many firms take a serious look at the problems of training and development. There is a fundamental need in the industry for positive employment policies. The growing technical sophistication of construction has not been matched by any parallel development in the handling of human and personnel resources. Thus there is an urgent requirement for proper personnel management.

Fellow and Langford (1983) identified that personnel management may be defined as the part of the management process concerned with human factors within the organisation. Such human factors will be ever present and the process of dealing with them is the principal function of personnel management.

Its objectives are:

- (a) to focus on the concern for people,
- (b) to optimise human resources with appropriate manning and effective working practices,
- (c) to provide conditions for promoting job satisfaction.

If the personnel function was to consider total quality management within an organisation it has to, for example, ensure that the right people with the right skills are doing the right things at the right time, in the right place, and in the right way.

Bentley stated (1991) that these objectives may only be met through significant planning skills or titled Human Resource Planning. The planning process would usually be considered as a two way function, either top-down or bottom-up. The top - down approach is where top management set the corporate objectives for the next

period and pass this down so that managers can set their own objectives to achieving the corporate goals. The other approach is the bottom - up approach with managers setting their objectives for what they believe they can achieve, and top management then fitting this into a corporate plan.

Bentley (1991) also explains that this impacts on human resource planning in two ways. Firstly line managers plan to use their existing people and then add to this the additional resources they think they will need during the planning period. Secondly the human resources or personnel function has to take account of the additional needs and produce a human resources plan, which considers the determined needs, selection and recruitment, training and development, placement, performance appraisal, promotion, succession and displacement. According to Schuler (1988), in order to get an overall picture of the interaction of these factors, they will have to be examined in relation to the training and development function.

#### ( i ) Determination of needs

Determination of needs is usually carried out in three stages; firstly: organisational needs where the organisation will examine all aspects of human resource development in relation to their short and long term strategies and objectives; secondly: job needs analysis which is performed by assessing the skills required to perform a particular job in the most efficient way and verifying the specification required for the job; finally the personal needs analysis which can be carried out with respect to employee performance, or in relation to identified training and development need for future jobs. The key question is whether the employee is able to do the current job efficiently. A very good example of this is when in 1992 the Institution of Civil Engineering provided a report listing the skills required at various stages of an engineer's career.

#### ( ii ) Selection and recruitment

Often the responsiveness of line management to the personal human resources manager will depend on his ability to provide the suitable person for a particular job or function within an effective labour force. Due to the peculiar operating characteristics of construction, autonomous production units require labour and management. It has been shown that many building firms recruit labour at site level without reference to overall company needs or when the organisation's needs analysis is being carried out. (Fellows and Longford, 1983)

#### ( ii ) Placement

The placement plan would be decided from looking at the vacancies in the training and development plans under determination of needs. and deciding who could fill which opening. The placement plan will of course have an effect on the recruitment plan and by judicious displacement in some departments, costly recruitment may be reduced.

#### ( iv ) Performance appraisal

Performance plans link closely with the training and development plans and should be reviewed regularly. The aim of these is to assess performance and to identify training needs and general personnel progress. This aspect leads on to promotion planning.

#### ( v ) Succession and displacement

The succession plan is linked in a way to the promotion plan, but is different in that a choice is made of who would succeed people currently in position. In this we can see another link for the training and development plan, where the successor will have to

know what the person in the post had been doing. A training plan would be an important factor for performing the new job efficiently (Fulmer, 1985).

## **2.4 Training and human resources development**

An important aspect of personnel management is training and development. Mangham and Silver (1986) pointed out what took place in British organisations, including construction firms, in comparison to some other industrialised countries. This was confirmed by a survey which examined the increasing awareness of the importance of training (Constable and McCormick, 1987). A further survey was carried out by Hughes (1990) to highlight the present need for training within the construction industry, and demonstrated that the survival of construction in the 1990s depended on management training.

Increasing management training can be achieved through improved supervisory training and increased long-term planning which could be a contributing factor in boosting field productivity in the construction industry. One of the most decisive trends reflected in the above survey is the relationship between management training and productivity. All firms surveyed believe training significantly improves productivity. An overwhelming majority of firms said management training is one of the main factors in increasing productivity, and also finding and keeping the best employee starts with effective management training in planning, communication and other related transferable skills.

Druker, (1996) argued that the recession of the early 1990s has severely effected the training function within the construction industry. Druker, (1996) further explained that some companies have gone to the extent of closing down their management



development centres in the past few years. A survey that was carried out by the CITB (Management Training Needs. 1989) in relation to the management training needs within the UK construction industry, gave similar results. The survey suggested that management skills were lacking in the construction industry and if quality and a better level of productivity was to be achieved much more training was required. This survey has further identified the needs for the training of managers and supervisors within the construction industry. The same survey also suggested that action is required through more development and training of managers and supervisors, if the construction industry were to substantially improve its performance and efficiency to satisfy their client's requirements.

The purpose of the survey of supervisory and management training needs in the UK construction industry was to identify the tasks, roles, responsibilities and training needs of those in occupations with supervisory and management functions in the UK construction industry. The key findings that emerged from the survey were major requirements for supervisory and management training related to business management, man management, and health and safety.

The above survey has also revealed that the organisations which engaged in structured management training were the very largest and even then this training is not always linked to formalised personnel appraisal schemes. Medium sized companies undertake some management training but on an in-house basis, as and when a particular need is identified. Small companies provided virtually no management training at all. Management development has to be a partnership between the company and the employee. The benefits of this would be significant in an industry dependent to a great extent on its labour force, as examined in the statistical tables of the Employment Gazette (1992).

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There has been some recognition of the shortcoming in training and the construction industry is striving to improve the training and development of its management and the labour force. Changing technologies, increased competition and the requirements of a well trained labour pool have spurred this need (Hughes, 1990). It has also been recognised that with training and development comes higher productivity, higher profit, improved quality, lower operating cost, more reliable estimates, greater problem-solving ability, more productive teams, and better internal and external communication skills .

Imbert (1991) points out further, that there is the increasing realisation that a skilled labour force is the construction industry's most precious resource and the skills of all construction workers, be they managers, designers or others, need continuous upgrading and updating.

This is what is known today as Human Resource Development. Garavan, Costine and Noreen (1995) defined human resource development as a means of planned learning and development of people as individual or groups to contribute efficiently to the company's overall objectives. There is a growing body of literature on the emergence and growth of human resource development especially on human resource development with a strategic focus. It was suggested that employee's values and philosophies should be guided by, and be consistent with, the strategies proposed by their own company. So human resource development is considered to be a relationship between human resource and company strategy. Within most formulations of human resource management, training and employee development represents the vital component.

It was suggested by Keep (1989) that the case for a strategic approach to training and development is vital to have significant meaning. Strategic human resource development considers that there is an overall objective for the organisation and that the human resource development effort should be related to it. It is essential to link organisation objectives to a planned learning experience so that people who question the value of human resource development also question the value of the company (Harrison, 1993).

Such development is not only essential for successful construction management but also has effects which reach far beyond the construction industry and influences economic planning policy, making technological progress and the provision and distribution of resources required for construction. The training and development function in the construction industry is not only important, but also essential if the industry is to survive and advance in a changing and competitive environment, while exposed to all types of different internal and external environmental forces. Encouragingly, Brewster and Hegewisch (1993) from recent surveys in the early 1990s, revealed that British companies seem to be taking training more seriously.

The above also stated that the Price Waterhouse Cranfield Project Survey indicated that training and staff development is the leading issue for most personnel departments across Europe, including the UK.

It is in this context that research is being carried out into present training methods within the construction industry on how it may be enhanced with the use of new technological methods.

### **2.4.1 The importance of training**

Filippo (1986) suggests that the purpose of training is to equip the employee with adequate knowledge, skills and the right attitude, as employees with increased knowledge and skills will give rise to the following effects.

#### **(a) Increased Productivity**

**An** increase in knowledge and skill will result in an increase in both quantity and quality of output. The increasing advancement of technology and changing of the nature of modern job, demands systematic training to enable employees to work competently.

#### **(b) Reduced Supervision**

A well trained employee can supervise himself or herself. Both employee and supervisor do not require close supervision, but it is not possible to have a greater interdependence and freedom in work unless the employee is adequately trained.

#### **(c) Increased organisational stability and flexibility**

Through training a reservoir of trained replacements can be created. Any loss of key personnel will not affect the stability of the organisation. In addition, multiple skills training should be provided to employees so that (if necessary) they can transfer to jobs with the highest demand. This will provide a means of flexibility for the whole organisation.

## 2.5 Training and human resource management

Fellows, Langford, Newcombe, and Urry, (1983) argued that as the total number of employees continued to decline in the past few years an increase has emerged in the administrative, professional, and managerial work. The increase in managerial work was related to increasing technical sophistication of buildings, and tighter construction budgets. This increase in managerial work has put more pressure on construction firms to develop their employee skills in order to match the changes which are taking place in their external environment and the realisation that this could only be done by the firm's willingness to provide technical and managerial training through their human resource management plans.

It is considered that the most important business resources are usually listed as people, money, systems, plant and equipment. And this has created a relationship between business requirements and workforce attitude. Armstrong (1990) explained that Organisations business strategies should be linked closely to its human resource management and development strategies as it is considered to be an important key factor to the organisation's success.

The term human resource management reflects significant developments in the application of behavioural science concepts .The term stresses management's role as a developer and user of human resources and, in turn, focuses squarely on applications. **Human** resource management has its antecedents in the personnel and industrial relations functions of most organisations. It emphasises the role of some primary staff functions such as selection, training, and compensation systems. It also recognises that effective utilisation of people is a basic management function of the

entire organisation, and it is equal in importance to any other function in the organisation.

Devanna, Fombrum and Tichy (1981) argued that human resource management mainly emphasises that people are the most important organisational resource, and they come first. It also has an increasingly strategic role in many organisations such as increasing concern about productivity and need for quality improvements. Indications of future shortages of trained people have highlighted the importance of effective human resource management. A comprehensive strategy for dealing with human resource issues will be necessary for most organisations.

Behavioural scientists have contributed many important concepts and research findings that are currently being applied through human resources management (Miles and Roseberg, 1982). Likert (1961) has suggested that human assets could be even more valuable than physical assets, and it should be carried on the organisation's balance sheet. After all each productive employee represents a considerable investment in recruitment and training , add to this the cost it would take to find, recruit, and train someone else to do the same job , and you can begin to see the significance of human resource accounting.

Likert (1961) further suggested, that in an economic recession, firms would be wiser to reduce inventories drastically and sell equipment than to dispose of their most important asset, people. We may not agree with that statement but at least it emphasises the importance of human resources. Recognition of the importance of training in recent years has been heavily influenced by the intensification of overseas competition and the relative success of economies like Japan, Germany and Sweden where investment in employment development is considerably emphasised.

Hall (1984) explained that technological development and organisational change have gradually led some employers to the realisation that success relies on the skills and abilities of their employees and this means considerable and continuous investment in training and development. This has also been underscored by human resource management with its emphasis on the importance of people and the skills they possess in enhancing organisational efficiency. Such human resource management concepts as 'commitment' to the company and the growth in the quality movement have led senior management teams to realise the increased importance of training employee development and long-term education. Nadler (1984) has seen this aspect of human resource management as so important to the extent of pointing out that human resource development should be regarded as being a discipline in its own right.

### **2.5.1 Identifying required skills**

The first step of vital importance in human resource development is the identification of needed skills and active management of employee learning for their long-range future in relation to explicit corporate strategies.

For training to be effective it is therefore necessary to discern the training needs not only of the individual and the group but how their needs fit the overall organisational objectives (Hall, 1984). Achieving this may be more difficult than it appears. Researchers and commentators are very dubious as to whether managerial hierarchies recognise the importance of these relationships in training initiatives or if they do, doubt whether they have the will or the ability to carry them out.



Many organisations invest considerable resources in training and development but never really examine how training and development can most effectively promote organisational objectives, or how development activities should be altered in the light of the plans.

Bernhard and Ingolis (1988) illustrated through the study of training and its strategic implementation in many companies, that a considerable amount of money is thrown away mainly because fundamental issues such as analysis of training needs in relation to the short and long-term plans had not been addressed. Such criticisms indicate that an integral part of analysing training needs is the recognition of what will fit the company culture as well as the company strategy and objectives, in other words the training scheme which may fit one company may not fit another and these company differences can only be ignored at great cost. Again this is part and parcel of the organic approach to human resource development (Fairbairn. 1991).

### **2.5.2 Determining required training**

Another important step in the management of training is to determine what training, if any, is required. Assessing the training needs of employees who are new to their jobs is a fairly straight forward matter. The main task is to determine what the job entails and to break it down into sub tasks, each of which is then taught to the new employee. But assessing the training needs of a present employee can be more complex. Here the need for training is usually prompted by problems, so you have the added task of deciding whether training is, in fact, the solution. Often, for instance, performance is down because the standards aren't clear or because the performance is just not motivated. The two main techniques for determining training requirements are task analysis and performance analysis. About 19% of employers

reporting in one survey said they used task analysis, which is an analysis of the job's requirements to determine the training required (Latham and Saari. 1979).

Job analysis is a method of evaluating job functions and is often used to discern the levels of skill necessary to do a job. However, it would be important to out point that Pickard (1992) suggested that there are many companies who have rejected such techniques, on the basis that they would prefer to reward individuals and not the job.

The information learned from such procedures can be useful in analysing the skill needs and requirement of the jobs. Task analysis is especially appropriate for determining the training needs of employees who are new to their jobs. About half the firms reporting said they used performance analysis to determine training requirements; this basically involves appraising the performance of current employees to determine if training could reduce performance problems such as low output.

Other techniques reportedly used to identify training needs included supervisor's reports, personnel records, management requests, observations, tests of job knowledge and questionnaire surveys. To some extent the training program should also reflect the firm's overall personnel plans, plans that are themselves derived from the goals of the enterprise. Thus, a construction firm's goal to get more involved in maintenance work means plans must be made for staffing these new activities; these plans will in turn require that the employee be selected and trained in order to perform these new activities.

Use of needs analysis methods should be used with caution as they could be too expensive in terms of time and money. A global review could end up producing

large amounts of paperwork unjustified by the returns gained. It is essential therefore to assess the cost-effectiveness of training needs analysis in relation to the outcomes and returns expected (Reid, Barrington and Kenney, 1992).

### **2.5.3 Setting training objectives**

Cicero (1973) strongly suggested that setting concrete measurable training objectives is the bottom line that should result from determining training needs. Well-written behavioural objectives specify what the trainee will be able to accomplish after successfully completing the training program. They thus provide a focus for the effort of both the trainee and the trainer, as well as a benchmark for evaluating the success of the training program (Goldstein, 1974).

### **2.5.4 Systematic training**

Armstrong (1990) defined systematic training as the term used to describe a rational approach to training and development based on : training policy, identification of training needs, planning and execution of training, and finally, the evaluation of training. The concept of systematic training originated with the Industrial Training Board in the late 1960s and is specifically designed to meet the defined needs. It is planned and provided by people who know how to train and then the impact of training is carefully evaluated.

Bass and Vaughan (1966) suggested that training is the systematic modification of behaviour through learning which occurs as a result of education, instruction, development and planned experience. Bass and Vaughan (1966), have further

defined learning as a relatively permanent change in behaviour that occurs as a result of practice or experience.

Nadler and Lawler (1983) have added that training in any organisation is an attempt to improve current or future employee performance by increasing through learning an employee's ability to perform, usually by increasing the employee's skills and knowledge, to remove deficiencies that cause employees to perform at less than the desired level. It enables employees to be much more productive, to reduce the learning time for employees starting in new jobs on requirements, displacements or promotions, and ensure that they become fully competent as quickly and economically as possible. In summary the role of training and development is ensuring that the organisation has the people with the correct mix of attributes, through providing appropriate learning opportunities, motivating people to learn. and enabling them to perform the highest level of quality and service (Bentley, 1991). The particular objectives of training are to develop the competence of employees and improve their performance, help people grow within the organisation in order that, human resource plans can be met within the organisation.

Pepper (1984) argued that the training process should normally take the familiar form of the following steps :

- (a) Identification of the training needs.
- (b) Specification of the steps to be taken and the training methods to be used to meet the need.
- (c) Detailed design of the specific training activities .
- (d) Conduct of the training so designed.
- (e) Evaluation of the impact of the training on the trainees and on the organisation as a whole.

Goldstein and Buxton (1982) explain that in relation to the construction industry, a labour force driven industry, training means investing in the labour force to enable them to perform better, and to empower them to make the best use of their natural abilities. In the long term nothing is more important for the construction industry than the quality of the labour force i.e. their education, and their training for skills in all its forms and levels. Goldstein and Buxton (1983) further summarise the main elements of most systematic training programmes :-

- (a ) Conducting need assessment analysis.
- (b) Deriving training programmes objectives.
- (c) Selecting training programmes methods.
- (d) Developing out some performance measure criteria.
- (e) Pre-testing or evaluation of trainees prior to training.
- (f)** Conducting training.
- (g) Monitoring and control of training.
- (h) Evaluation of trainees after training.
- (i) Conducting overall training programme, evaluation and drawing-up of recommendations.

These steps could be applied to most training plans and be oriented to suit different training programmes for different construction firms.

Another way of presenting systematic training is the model applied by the industrial engineering division of a large engineering company (Reda, 1989) and shown in figure 2.2. A system approach to industrial engineering review was adopted and in

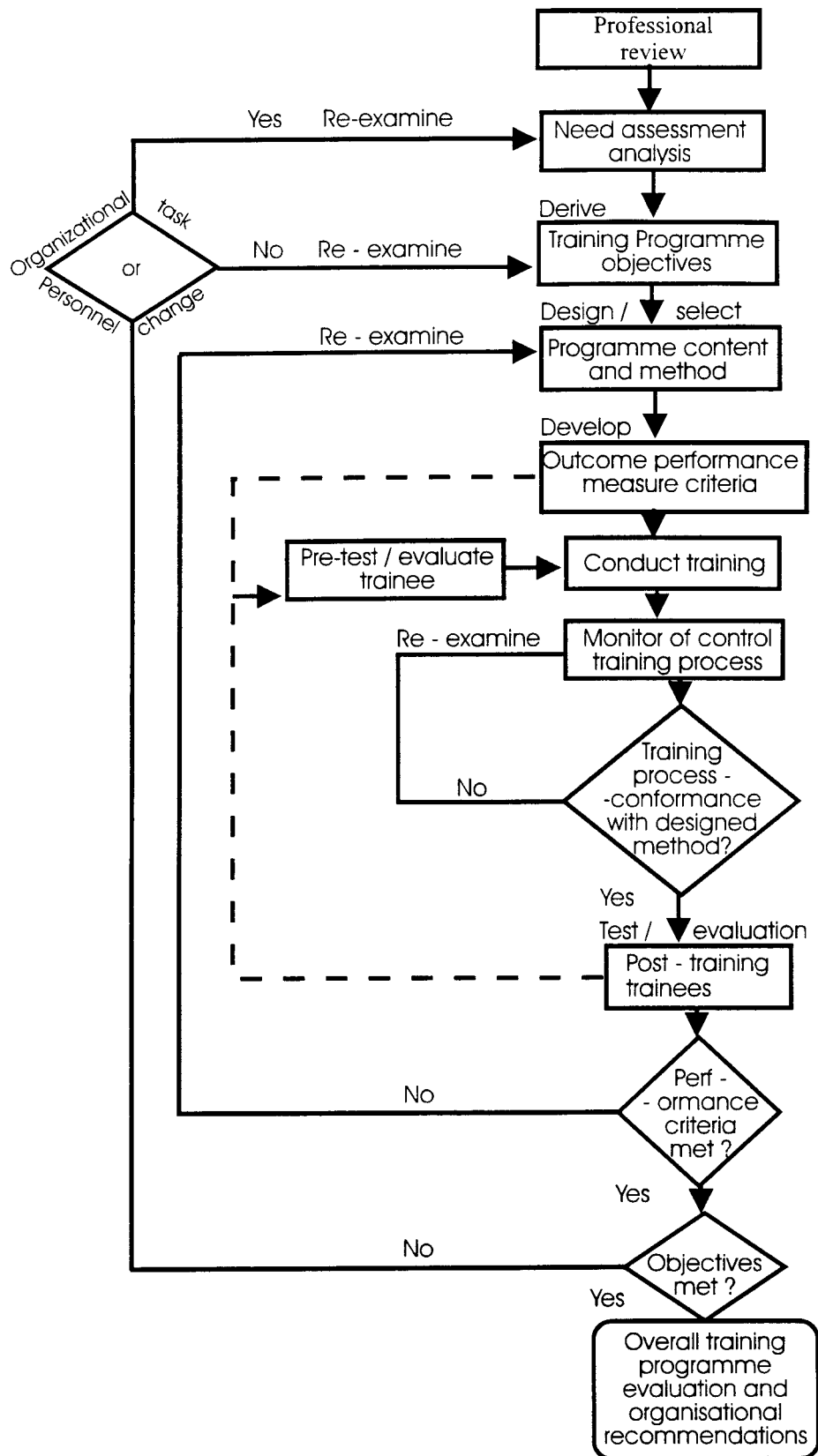


Figure 2.2 Systematic Training Programme Model

Adopted from : H.M.Redha, Journal of European Industrial Training.

this model the system approach is emphasised more through a sequence of steps linked by feedback diagnostic and control loops.

## **2.6 Computer based training**

Computers have been used for educational and training purposes for more than 30 years. During the 1960s, significant resources were invested in the development of computer-based learning systems following principles derived from programmed learning. Since then, the range of philosophical, pedagogical, and technical approaches to the educational use of computer has broadened very substantially. Educational applications in which the computer actually takes on a recognisable teaching role are currently in the minority. Cutting across the styles of application, it was found that there are different technological orientations. As far as expert systems are concerned, its methods and tools are being applied to straightforward expository systems as well as to learning environments designed with the intention of promoting learning by discovery (Lawler & Yazdani 1987).

Many firms are now using computers to facilitate the training process. An example of that is the computer-assisted instruction (CAI) systems. They provide self paced individualised instruction that is one-on-one and easy to use, and trainees get immediate feedback to their input. CAI also provides accountability in that tests are taken on the computer so that management can monitor each trainee's progress and needs.

A CAI training program can also be easily modified to reflect technological innovations on the knowledge for which the employee is being trained. CAI training also tends to be more flexible in that trainees can usually use the computer almost

any time they want, and thus get their training when they prefer. The computer as a teaching machine is best known in the use of the computer in instruction is as a "teaching machine". This is commonly referred to as computer-aided instruction or CAI. The computer can help a trainer or an instructor deliver instructional content and develop learner skills in a number of ways. A well known example in this field of CAI is the PLATO system. The PLATO system, first introduced in 1959, was a pioneering tool in the development of CAI. PLATO was originally designed for use with a mainframe, but it has more recently been adapted for personal computers. Using PLATO and other systems, programmers and trainers developed CAI for tutorial of academic disciplines. It has also been used for training in different industries and as an educational tool (Heermann 1988).

Intelligent tutor systems are considered to be a step beyond traditional computer-assisted instruction by passing three tests of intelligence. Firstly, the subject matter, or domain, must be known to the computer system well enough for this embedded expert to draw inferences from the domain. Secondly the system must be able to increase a learner's understanding of that knowledge. Thirdly, the tutorial strategy must be intelligent in that the expert knowledge in the knowledge base would help to reduce difference between expert and learner performance. The focus of this research is on the expert module of a tutor that provides training in a domain intelligence (Polson 1988).

An expert system may be defined as a computer system that achieves high levels of performance in task areas that, for human beings, require years of training and education (Hays-Roth et al. 1983). Expert systems have developed from the field of Artificial Intelligence (AI). The application of AI to education has given Intelligent Computer Assisted Learning (ICAL) of which tutor expert system are part. Tutor



expert systems are considered to be tools of CAL although tutor expert systems tend to rely mainly on experts knowledge in the design of its knowledge base (Goble 1987). (detailed features of expert systems can be seen in chapter 4).

An important step in building an expert system. knowledge engineers need to decide on the appropriate modality for the proposed expert system. e.g., diagnostic expert, tutor expert. That usually would depend a great deal on the task which is required from the expert system. In the case of training/learning the tutoring expert model would be most appropriate for building such a system as the expert system here would be expected to provide knowledge and train the individual (Kidd 1987).

So computers can be used in training :

- ( i ) To simulate actual situations in order that trainees can learn by doing. That is usually carried out using historical data gained from previous projects which the organisation has performed.
- ( ii ) To extend programmed learning texts to provide diagrammatic and pictorial displays in colour and to allow more interaction between the trainee and the information presented on the screen.
- ( iii ) To provide a database for information which trainees can access through a computer terminal.
- ( iv ) To measure the performance of trainees against pre-defined criteria.
- ( v ) To provide tests or exercise for trainees.

The use of computers in training can also provide systems and facilities to enable organisations (industry and training institutes) in setting up network based training centres. These centres can effectively accommodate the constant changing and

increasing training needs by means of flexible and distance learning. The use of computers in training has been applied to developing an environment for in-company-and institutional training centres and facilitating flexible delivery of education and training. Environments for learning are being applied more and more particularly for in-company and institutional training. In such an environment the trainee will be allocated to specific courses, learning material will have to be delivered, results will then be assessed and made available for future evaluations. This kind of environment should support organisations on the management level, trainer level (on line tutoring and monitoring) and trainee level (learning support) (Commission of the European Communities, 1991).

## **2.7 Evaluation of training**

Evaluation is an essential part of the learning process. Without it there can be no certainty that a learning event has achieved its objectives. Smith and Mackness (1992) viewed this stage as it can be both simplistic and complicated. It can be seen as simplistic in that monitoring is a process whereby information is gathered from the trainees and then the course and programs are amended in the light of these comments. It is in fact far more complex because there are other parties in the process besides the trainees, i.e. designers of the training course, the trainers and the sponsors. Each have their own purpose, aims and objectives and they must be clearly identified before evaluation can proceed. Buckley and Caple (1990) further defined evaluation as the "the process of attempting to assess the total value of training: that is the cost benefits and general outcomes which benefit the organisation as well as the value of the improved performance of those who have undertaken training". Phillips (1990) argued that evaluation of training should also be considered to be part of the control process of training. Evaluation methods aim to obtain feedback about

the results or outputs of training, and to make full use of this feedback to assess the value of the training. Also evaluation of training can be regarded as the systematic and impartial collection of data for managers and all other interested parties. This information equips them to draw conclusions about the effectiveness of particular training measures as a way of achieving organisational objectives, implementing policy and promoting organisational learning. There seems to be widespread agreement with the proposition that evaluation of training is the least well conducted aspect of all training activities.

A recent study of training in UK firms revealed that 85 percent of British employers make no attempt to assess the benefits gained from undertaking training (H.M. Stationery Office, 1989). Effective training must have value for the organisation. Evaluation carried out after training programs should consider the following factors:

- (a) The context within which the learning event has taken place.
- (b) How accurately needs were assessed.
- (c) Why choosing such a kind of learning as a solution is appropriate.
- (d) Finally how and what training objectives were set.

The inputs to training events should also address the following three factors :-

- ( i ) The resources that were available for the event i.e. time, personal, natural training resources.
  - ( ii ) The reactions to the training event by trainees involved, especially in relation to the reaction that it was originally intended it should achieve.
  - ( iii ) The outcome of the training event: the effect of that event by reference to the objectives set for it and the outcomes it has actually achieved
- (Harrison 1990).

## **2.8 Learning styles**

The first aim of any learning environment or training course will be to provide trainees with additional (technical) knowledge. So learning can be defined as the literal retention of knowledge often achieved through repetition and recitation, while another might describe it as an interpretative process aimed at understanding reality. For that additional knowledge to make sense it has to be based on adequate prior knowledge (Dochy 1992). This will depend a great deal on the learning style which this environment is attempting to support.

There are three broad perspectives on learning which can be distinguished: the experiential perspectives, the behavioural perspectives, and the neurological perspectives.

From the experiential perspective, learning is defined by individuals engaged in learning. The learners describe their experience of events involved in learning. Learning can be categorised in several ways, as learners experiences differ from one another. At the extremes one learner might describe learning as the literal retention of knowledge often achieved through repetition and recitation, while another might describe it as an interpretative process aimed at understanding reality.

From the behavioural perspective, learning is an observable change in a person's reaction to an equally observable stimulus situation. This change in reaction or in behaviour is usually relatively permanent once it has been learned. (MARTEN, 1984).

Finally, from the neurological perspective learning is the process whereby the nervous system is transformed by its own activity. It results from the tracks left behind by thoughts. Neural activity changes the neurones that are active, and that change is the structural basis of learning. The change occurs as a direct result of the neural activity itself, that is, as a direct result of processing information. (McCarthy 1982). That is, learning can be considered with reference to: the proportion of the learner, its externally measurable behavioural manifestation, or its underlying physical Substrate in the brain.

A more specific concept in the area of education was that of "approach to learning" introduced by Marion (1976) to describe what he saw as a fundamental difference in the focus of attention of learners reading texts.

In the deep approach the learner starts by extracting personal meaning from the presented knowledge and this leads to an active process of learning in which the learners challenge the ideas, evidence, and arguments presented by that knowledge. This, in turn, implies that the learner is reconstructing knowledge within a personal framework intending to establish a network of meaningful connections between the new information and previously established information.

In a "surface approach" however the learner is usually concerned with verbatim recall of either the whole text or the facts and ideas presented in it. There is little or no personal engagement in the act of learning: it is seen as an external imposition. Learners are thus concerned more with task completion than with improving their knowledge and skills. They are unlikely to relate evidence and conclusions or examine the argument in a critical way.

Svensson (1976) suggested that the process of learning thus can be seen as sequential in that it fails to include the crucial stage of reorganisation and reinterpretation. and the outcome is more or less complete reproduction of the text, which is unlikely to contain the central core of the author's message.

Svensson (1976) summarised the main points in the two categories as follows :

( A ) Deep approach

- i Intention to understand material for oneself.
- ii Relating ideas to previous knowledge and experience.
- iii Using organising principles to integrate ideas.

( B ) Surface approach

- i Intention simply to reproduce parts of content
- ii Accepting ideas and information passively.
- iii Concentrating only on assessment requirements
- iv Not reflecting on purpose or strategies.
- v Memorising facts and producing routinely.
- vi Failing to distinguish guiding principles or patterns.

Marton (1997) explains further that the different approach to learning can help in analysing learner understanding of a particular knowledge. If the outcome of learning differs between individuals, then the very process of learning which leads to different outcomes must also have differed between individuals. The most obvious explanation of the differences in the outcome should derive from a description of the differences in the process that led to the different outcomes

A significant prerequisite for attempting to influence how learners act in learning situations is to have a clear grasp of precisely how different learners act. The problem could be phrased as : what is it that a reader/learner using a deep approach does differently from a person using a surface approach. That will depend a great deal on what the learner is trying to accomplish. The picture outlined so far indicates that a significant component of a deep approach is that the reader/learner engages in a more active dialogue with the text. The questions that could be considered in this case is: how do the various sections of the knowledge relate to each other? Is the argument consistent or are there any logical gaps? How does this relate to what the learner already know?. One of the problems with a surface approach is the lack of such an active and reflective attitude towards the text, and leads to the idea of inducing a deep approach through giving learners some guidelines on how to go about learning. Deep approach could be implemented in a learning environment by getting the learners to build relationships between the various sub-sections and to be able to structure the text being presented in order to obtain a meaningful knowledge.

## **2.9 Summary**

This chapter examines the practicalities of training, and identifies that although there has been a growing recognition of the need for training in many construction companies, controversy still exists as to the extent and quality of training required.

Training is seen as a key instrument in the implementation of human resource management policies and practices, particularly those involving cultural change and the necessity of introducing new working practices. Another point which was raised in this chapter is the recognition of individual training needs. This may, however, clash with organisational needs, and so in order to proceed with training within any

company both individual and organisational needs must be considered and a mutual benefit be derived. Another part of this chapter deals with the partialities of creating a human resource development plan. The first and most important step in a human resource development plan is to analyse the training need of the organisation in relation to the organisation's strategy and also relate this to the needs of the individuals within the organisation.

The last part of the chapter deals with evaluating and monitoring the training process. This section considers the objectives behind the evaluation and the method in which the evaluation can be carried out, where the results obtained later from such training evaluations should feedback into the human resource development process to improve the training effectiveness.

The next chapter will examine the current situation on management training and attitudes towards the use of computers within the construction industry. The work was carried out in the form of a survey, in order to get a real feel for the theoretical material which has been examined in this chapter.



## **Chapter 3      Civil Engineering and Management Training**

### **3.1 Introduction**

In the pervious chapter the management of training has been looked into as one of the important elements in human resource development and how it should be planned and implemented within an organisation, as a main managerial function. Chapter three highlights the importance of training management needs in civil engineering organisations. In order to get a feel of the need for training and the use of computer technology within construction organisations, a survey was conducted which looked into training in management and the usage of computing in construction and civil engineering firms. The survey took the form of a questionnaire to selected organisations. The survey was part of a wider investigation than the work in this theses, and therefore within this chapter, only responses to questions relevant to the work here, will be examined. An initial interviews were conducted by Scott (1993) and identified the variable (listed below) and piloted with selected people. The interviews were not included as they were not part of this thesis.

### **3.2 Objective of survey**

The questionnaire was aimed at exploring the opinions and attitudes of the respondent towards management training and the use of computers in the construction industry as a whole. In order to start exploring those areas a wide range of information would be collected first, followed by a targeting of two specific areas of management training and computing. A number of categories of information were

highlighted that would provide a degree of general knowledge about companies and their policies. The highlighted categories are as follows :-

- ( I ) History and evaluation of company
- ( II ) Structure of company
- ( III ) Types of work undertaken
- ( IV ) Methods of finance
- ( V ) Personnel-recruitment and training
- ( VI ) Use of computer transfer technology

### **3.3 Survey Structure**

The survey was carried out in two stages to optimise the survey.

Stage 1- First letter to companies

This letter was designed to meet two objectives. The first objective was the collection of general company data, and the second was to describe the research being carried out and to inform the participants that they would be receiving a set of questionnaires regarding this matter. The letter also included the general categories (which will be mentioned at a later point of this chapter) in which the companies were asked to provide general information about their companies in the form of brochures or any other form of their choice.

Stage 2- Second letter and questionnaire

From the information obtained from the initial letter, the specific areas to be examined in detail were decided upon. Once this had been done a list of questions was compiled mainly on attitudes to management training and computer technology.

### **3.4 Design of questionnaire**

Questionnaire has been used in the survey as the main source of information in respect to other methods such as in interviews, in order to guarantee a large response to the survey. The questionnaire was designed to 'good practice' and described in detail in Scott (1992). The design is therefore not described within this thesis. The questionnaire was Piloted and designed to examine different aspects but connected areas of management. Only responses to questions which are relevant to this research shall be examined in this chapter. The questions which are relevant are numbers Q8, Q9, Q9a, Q13, and Q14 ( the questionnaire can be seen in appendix ( G ).

The questions were based on the following two elements :

( a ) Training in management :

e.g. training schemes, organisation of training

( b ) Attitudes to computers :

e.g. computing as a technology, feelings of using a computer .

#### **3.4.1 Selection and Sampling**

The selection process which was employed in this survey can be described as follows.

( a ) The addresses of as many civil engineering companies as possible were obtained from the following sources:

( i ) Contractors file (1990)

( ii ) Index of Employers Approved for Training (1991)

( iii ) Roget (1989 and 1992).

All addresses were selected from reference Roget (1992), which provides the name and address of over 2300 British companies.

( b ) A selection was then made in a random fashion from the Contractors file (1990) and the Index of Employers Approved for Training (1991) to make the numbers of contractors and Consultants equal. The final size of the sample was 179. This figure consisted of approximately half contractors and half consultants and covered the complete range of sizes of companies from the smallest to the largest.

( c ) A judgement sample was then used in selecting sample units from all companies, treating each company as a single unit.. A judgement sample is one where a representative sample is selected using certain criteria. This method is common in industrial research. The sample was based on equal probability principles and a single stage approach was used in the two stages as discussed previously.

### **3.4.2 Analysis of questionnaire response**

From stage one eighty six replies were received which is an overall response rate of forty nine percent. For stage two, ninety one replies were received which represents response rate of fifty one percent. Both percentages are considered to be very good for this type of survey. A break down of the response rates for contractors and consultants is shown below :

Stage	All	Consultants	Contractors
1	49.4%	36%	58.7%
2	50.6%	55.7%	44.6%
Total approached	174	79	92

Table 3.1 Total response to questionnaire  
(Theses figures are based on the corrected sample size of 174 companies)

These figures are based on the correct sample size of 174 companies. 179 were initially targeted but five were then found to have undergone mergers or had ceased to exist. Three of the 174 are institutes and have not been included in the calculations.

A significant difference can be seen between the contractors and consultants as regards the response rates. The low figure obtained for the consultants in stage 1 may be due to the reluctance of many consultants to reveal information about themselves. Scott (1993) confirmed this in subsequent interviews where the consultants seemed particularly worried about giving the turnover and employee figures. A number of the smaller consultants may not actually produce brochures so they have been unable to offer help on this point. Although their willingness to participate is borne out by the high return rate to stage 2.

The information returned in the brochures, newsletters, books, reports and papers was of important value but there was also a vast amount of it. Only a very small part of this information was extracted for use in the analysis. The remaining data formed the broad base of knowledge that was necessary to determine the path that the survey should follow. It was from this information that the final decision on what topics to look at in detail was made.

The following variables were extracted from the information gathered from companies in stage-1 of the survey. (see 3.3 survey structure). The data extracted for analysis was combined with the data obtained from the questionnaire. It consisted of the following variables :

( a ) Age of company

( b ) Turnover of company

( c ) Number of employees

( d ) Number of expertise

( e ) Location of company

### 3.4.2.1 Company age

From Figure 3.1 it can be seen that a full distribution of the ages of the companies was obtained. The age of the company has been considered a factor in examining the policy on management training.

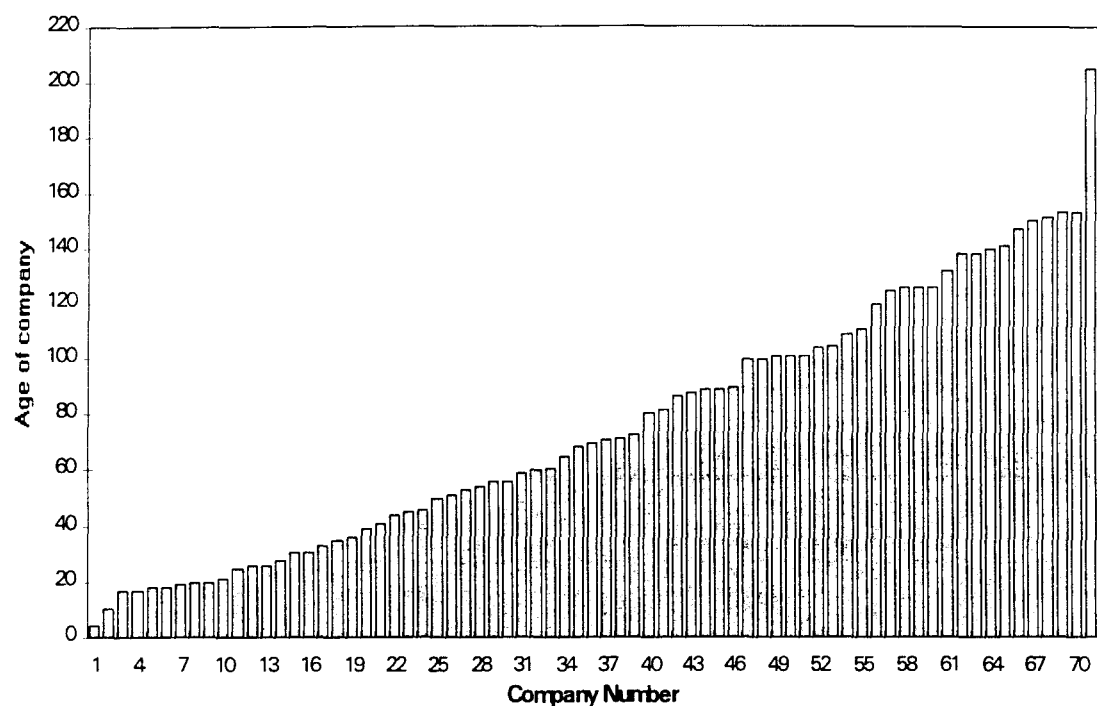


Figure 3.1 Full distribution of companies ages

### 3.4.2.2 Company turnover

Figure 3.2 presents the range of turnovers for the companies that responded to the questionnaire. It can also be seen that the turnover of the contractors was larger than the consultants by a factor of ten. The recorded company turnover categories were a

further factor used in the company's management training analysis. Other factors could have been used in the company's management training analysis such as the number of employees. but that information was not readily available.

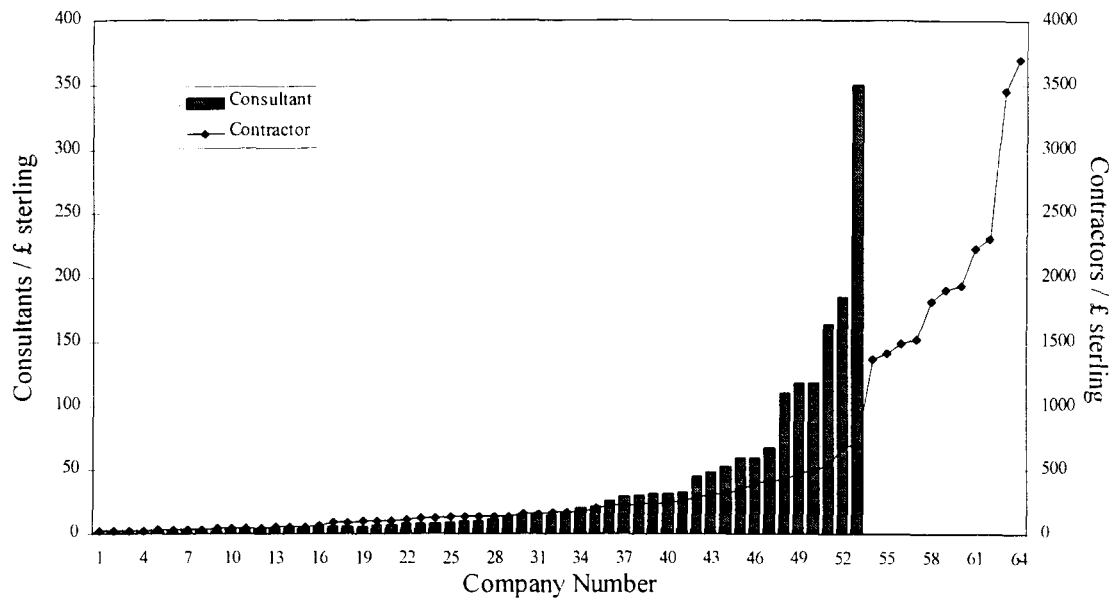


Figure 3.2 Turnover of contractors & consultants

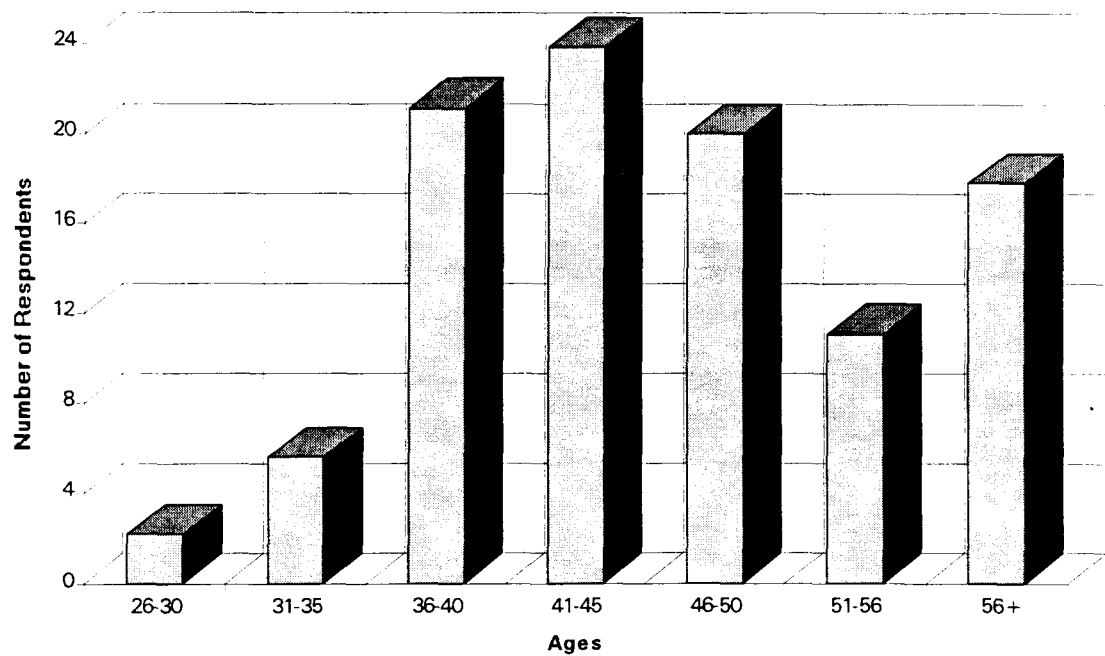


Figure 3.3 Age of respondents

### 3.4.2.3 Respondent age

The questionnaires were for the most part sent to relatively senior personnel, and as a result relatively older. As shown in figure 3.3 only 7.8% of respondents were under the age of thirty six. This may present a slightly biased view of attitudes towards management training and computer technology in favour of the older respondents.

### 3.4.2.4 Civil engineering experience

The experience of the respondents is very closely linked to their age and as such only 18% (as shown in figure 3.4) of the respondents have been in the industry less than sixteen years. The older respondents who have only been involved with the construction industry for a short while tended to be non engineers.

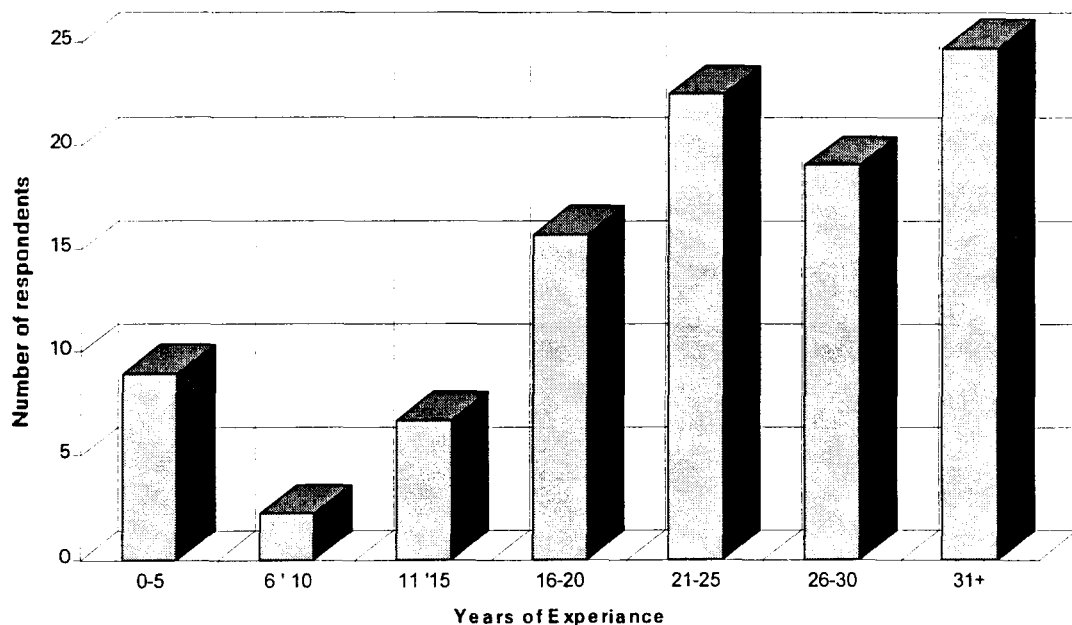


Figure 3.4 Years of civil engineering experience.

Experience in the construction industry is a very useful variable for determining if



Interestingly the experience within a company did not reflect the experience in general. From figure 3.5 it can be seen that there is a fairly even spread across all the categories. Fewer people are likely to spend over thirty years with the same company, which is to be expected.

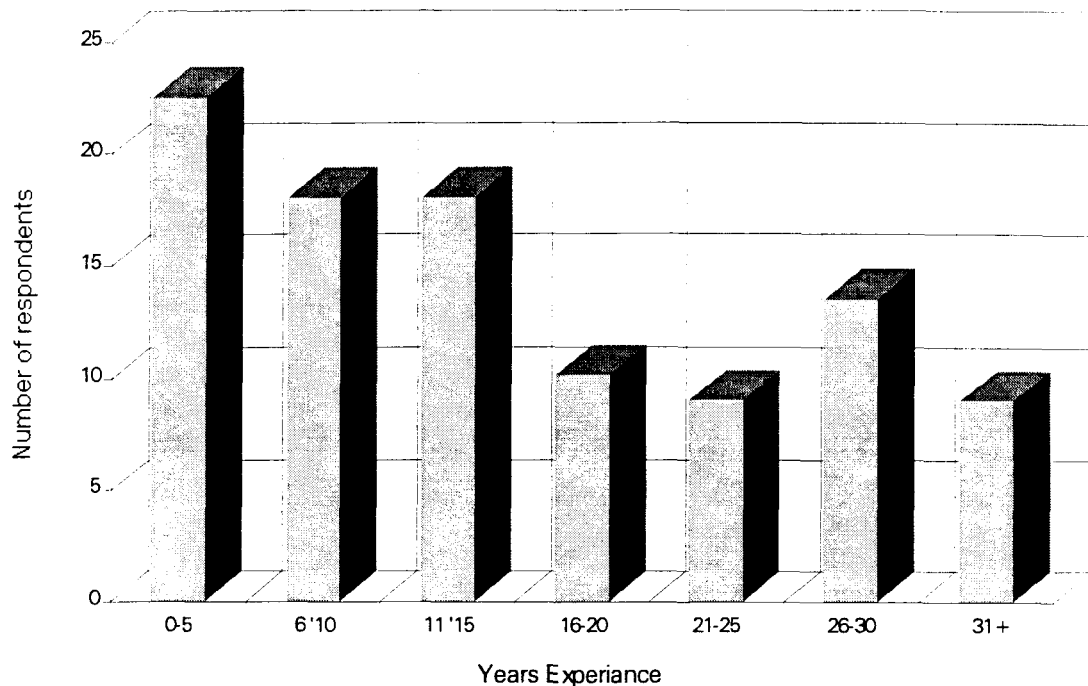


Figure 3.5 Years of respondent's experience with companies.

the attitudes of the older generation are significantly different from the younger respondents, but unfortunately this comparison will not be possible because of the bias towards the older generation.

#### **3.4.2.5 Company experience**

A number of the respondents in the most senior positions had only been with that company a short period of time (less than five years). There appears to be a tendency to move between companies at all stages in a career.

### 3.5 Management training

This section examines the questions that were asked in the questionnaire which looked into management training in the construction industry (Q8, Q9 and Q9a ). Question 8 asked the participants if they have participated in any management training schemes. Question 9 and 9a asked the participants if their companies use management training schemes, and if so are those schemes usually organised by their companies or by other companies.

#### 3.5.1 Individuals attending management training courses.

Comparing the total row percentages in tables 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, it can be seen that there is a major difference in the figures between the consultants and the contractors. Table 3.2 shall be considered as an example to explain the way in which percentages of responses were calculated in the tables presented in this chapter.

The "YES" responses (31-35 age group)

**Count** is the participants responses to questionnaire in different age groups.

i.e. count response in this case is  $C1 = 1$ .

**Total Row** is the sum of all the row responses in all different age groups, which =I 1.

where  $I1 = B1 + C1 + D1 + E1 + F1 + G1 + H1$

$I1 = 0 + 1 + 7 + 7 + 2 + 1 + 4$

$I1 = 22$

**Row Pct** : is the row count of responses in a particular age group \* 100 / total row count of responses in all age groups.

i.e.  $C2 = (C1 * 100) / I1$

$C2 = (1 * 100) / 22$

**Col Pct:** is the column count of responses in a particular age group  $\times 100 /$  total column count (yes and the no responses) in the same age group.

$$\text{i.e. } C3 = (C1 \times 100) / C11$$

$$C3 = (1 \times 100) / 2$$

$$C3 = 50\%$$

**TolPct:** is the count number / the total column and row count number (which is I11)  $\times 100$

Where I11 = Total column responses count

$$\text{i.e. } B11 + C11 + D11 + E11 + F11 + G11 + H11$$

and

Where I11 = Total rows response count (YES & NO).

$$\text{i.e. } I1 + I6$$

$$\text{i.e. } C4 = (C1 / I11) \times 100$$

$$C4 = (1 / 43) \times 100$$

$$C4 = 2.3\%$$

The "No" responses

**count** is the participants responses to questionnaire in different age groups.

i.e. count response in this case is  $C6 = 1$ .

**Total Row:** is the sum of all the row responses in all different age groups, which = i6.

$$\text{where } i1 = B6 + C6 + D6 + E6 + F6 + G6 + H6$$

$$I6 = 1 + 1 + 4 + 4 + 2 + 3 + 6$$

$$I6 = 21$$

**Row Pct** : is the row count of responses in a particular age group  $\times 100 /$  total row count of responses in all age groups.

$$\text{i.e. } C7 = (C6 \times 100) / I6$$

$$C7 = (1 \times 100) / 21$$

$$C7 = 4.8$$

**ColPct** : is the column count of responses in a particular age group \*100 / total column count (yes and the no responses) in the same age group.

$$\text{i.e. } C8 = ( C6 * 100 ) / C11$$

$$C8 = ( 1 * 100 ) / 2$$

$$C8 = 50$$

**TolPct**: is the count number / the total column and row count number (which is I11) \* 100

Where I11 = Total column responses count

$$\text{i.e. } B11+C11+D11+E11+F11+G11+H11$$

and

Where I11 = Total rows response count (**YES& No**).

$$\text{i.e. } I1 + I6$$

$$\text{i.e. } C9 = ( C6 / I11 ) * 100$$

$$C9 = ( 1 / 43 ) * 100$$

$$C4 = 2.3 \%$$

Overall **61%** of respondents had attended a management training course. While 70% of contractors had attended management training courses only. **51%** of consultants has attended similar courses. In order to get a closer picture of that difference (between the contractors and the consultants in attending those courses), different factors had to be considered. A break down of returns was carried out using the following factors of age, years in industry, years with the company and (the) engineer or non engineer .

● *Age.*

Tables 3.2 and 3.3 shows that the age of the respondents appears to play a significant part in the attendance of management training courses. Table 3.2 shows clearly that the older respondents are less likely to attend such courses, i.e. 60% of consultants over the age of 56 and **75%** in the age group of 51 - 55 had not participated.

	A	B	C	D	E	F	G	H	I
					<b>AGE</b>				
		26-30	31-35	36-40	41-45	46-50	51-55	56 +	Total
	<b>YES</b>								
1	Count		1	7	7	2	1	4	22
2	Row Pct		4.5	31.8	31.8	9.1	4.5	18.2	51.2
3	Col Pct		50	63.6	63.6	50	25	40	
4	Tot Pct		2.3	16.3	16.3	4.7	2.3	9.3	
5	<b>No</b>								
6	Count	1	1	4	4	2	3	6	21
7	Row Pct	4.8	4.8	19	19	9.5	14.3	28.6	48.8
8	Col Pct	100	50	36.4	36.4	50	75	60	
9	Tot Pct	2.3	2.3	9.3	9.3	4.7	7	14	
10									
11	Total Column Count	1	2	11	11	4	4	10	43
12	Total Pct	2.3	4.7	25.6	25.6	9.3	9.3	23.3	100

Table 3.2. Management Training by Age (Consultants)

The age groups which are likely to attend training courses among the consultants are the 36-40 groups, and the 41-45, both at 63% of the total. Comparing both tables 3.2 and 3.3 shows that there were only two respondents in the 26 - 30 age group. One was a contractor and one a consultant. Both respondents had not attended management training courses. This could be due to the fact that it was too early in their careers to have attended such courses. The contractors participation in management training courses is higher and shown in table 3.3. All contractors over the age of 50 had attended, 71% of the 46 -50,55% of the 41 - 45 and 62% of the 36 - 40 age groups.

				AGE				Row
	26-30	31-35	36-40	41-45	46-50	51-55	56 +	Total
<b>YES</b>								
Count		1	5	5	10	6	6	33
Row Pct		3	15.2	15.2	30.3	18.2	18.2	70.2
Col Pct		33.3	62.5	55.6	71.4	100	100	
Tot Pct		2.1	10.6	10.6	21.3	12.8	12.8	
<b>NO</b>								
Count	1	2	3	4	4			14
Row Pct	7.1	14.3	21.4	28.6	28.6			29.8
Col Pct	100	66.7	37.5	44.4	28.6			
Tot Pct	2.1	4.3	6.4	8.5	8.5			
Total Column Count	1	3	8	9	14	6	6	47
Total %	2.1	6.4	17	19.1	29.8	12.8	12.8	100

Table 3.3 Management Training by Age (Contractors)

The difference is clear and it reflects the attitudes towards management training between contractors and consultants.

● *Years in industry.*

Examining table 3.5 for the contractors, it can be seen that as the respondents gain experience they tend to acquire more managerial skill through increased responsibilities. In order to cope with the increased responsibilities, they have to improve their managerial skills by attending management training courses. As mentioned before there is a close link between the respondent's age and time spent in the construction industry, as was to be expected. Therefore tables 3.4 and 3.5 reflect this linkage. By examining the consultant's figures in table 3.4 it can be seen that many respondents who have been in the construction industry for over 31 years have not attended management training courses.

	YEARS							Row Total
	0-5	6-10	11-15	16-20	21-25	26-30	31+	
<b>YES</b>								
Count	1	1	3	3	7	3	4	22
Row Pct	4.5	4.5	13.6	13.6	31.8	13.6	18.2	52.4
Col Pct	50	100	75	42.9	63.6	60	33.3	
Tot Pct	2.4	2.4	7.1	7.1	16.7	7.1	9.5	
<b>NO</b>								
Count	1		1	4	4	2	8	20
Row Pct	5		5	20	20	10	40	47.6
Col Pct	50		25	57.1	36.4	40	66.7	
Tot Pct	2.4		2.4	9.5	9.5	4.8	19	
Column	2	1	4	7	11	5	12	42
Total %	4.8	2.4	9.5	16.7	26.2	11.9	28.6	100

### 3.4 Management training by years in industry (Consultants)

The contractors responses in table 3.5 show that they (tend to) have covered more management training courses, in particular the senior contractors. This again shows that the consultants are behind in attending management training courses.

	YEARS							Row Total
	0-5	6-10	11-15	16-20	21-25	26-30	31+	
<b>YES</b>								
Count	4		1	4	6	9	9	33
Row Pct	12.1		3	12.1	18.2	27.3	27.3	70.2
Col Pct	66.7		50	57.1	66.7	75	90	
Tot Pct	8.5		2.1	8.5	12.8	19.1	19.1	
<b>NO</b>								
Count	2	1	1	3	3	3	1	14
Row Pct	14.3	7.1	7.1	21.4	21.4	21.4	7.1	29.8
Col Pct	33.3	100	50	42.9	33.3	25	10	
Tot Pct	4.3	2.1	2.1	6.4	6.4	6.4	2.1	
Column	6	1	2	7	9	12	10	47
Total %	12.8	2.1	4.3	14.9	19.1	25.5	21.3	100

### 3.5 Management training by years in industry (contractors)

● *Years with company.*

Similar results can be obtained from tables 3.6 and 3.7. Table 3.6 clearly shows that no consultant who has been with the same company for over 31 years has attended any management training courses.

	YEARS							Row Total
	0-5	6-10	11-15	16-20	21-25	26-30	31+	
<b>YES</b>								
Count	3	6	4	4	2	3		22
Row Pct	13.6	27.3	18.2	18.2	9.1	13.6		52.4
Col Pct	50	66.7	50	100	50	50		
Tot Pct	7.1	14.3	9.5	9.5	4.8	7.1		
<b>NO</b>								
Count	3	3	4		2	3	5	20
Row Pct	15	15	20		10	15	25	47.6
Col Pct	50	33.3	50		50	50	100	
Tot Pct	7.1	7.1	9.5		4.8	7.1	11.9	
Column	6	9	8	4	4	6	5	42
Total %	14.3	21.4	19	9.5	9.5	14.3	11.9	100

3.6 Management training by years with company (Consultants)

This result points out that people at decision making level (management level) are not receiving appropriate managerial training (Scott, Ponniah & Saoud 1994). This results looks similar to the results appeared in the management development report of the Institution of Civil Engineers in 1992. The report explained that there was a need for more purposeful management training and development both in industry and the professions. The report developed an assessment scheme. It is aimed primarily at the construction industry, but is also of use to all engineering disciplines.



	YEARS							Row Total
	0-5	6-10	11-15	16-20	21-25	26-30	31+	
<b>YES</b>								
Count	9	2	5	4	4	6	3	33
Row Pct	27.3	6.1	15.2	12.1	12.1	18.2	9.1	70.2
Col Pct	64.3	28.6	62.5	80	100	100	100	
Tot Pct	19.1	4.3	10.6	8.5	8.5	12.8	6.4	
<b>NO</b>								
Count	5	5	3	1				14
Row Pct	35.7	35.7	21.4	7.1				29.8
Col Pct	35.7	71.4	37.5	20				
Tot Pct	10.6	10.6	6.4	2.1				
Column	14	7	8	5	4	6	3	47
Total %	29.8	14.9	17	10.6	8.5	12.8	6.4	100

### 3.7 Management training by years with company (Contractors)

This could have a significant effect on the running of their companies and on their performance in managing such companies. Table 3.7 shows clearly that nearly all contractors who have been with the same company for over 20 years have been on management training courses. This result shows that contractors tend to regard management training courses as an important element to assist them in their decision making, and the management of their companies.

#### ● *Engineer or non-engineer*

The following section deals with the way in which consultants and contractors are divided within the construction industry. The figures in table 3.8 shows that (by adding the engineer total percentages of **46.5%** and 39.5%) **86%** of the responses from consultants have an engineering background.

			Row				Row
	Engineer	Non-engineer	Total		Engineer	Non engineer	Total
<b>YES</b>				<b>YES</b>			
Count	20	2	22	Count	18	15	33
Row Pct	90.9	9.1	51.2	Row Pct	54.5	45.5	70.2
Col Pct	54.1	33.3		Col Pct	66.7	75	
Tot Pct	46.5	4.7		Tot Pct	38.3	31.9	
<b>No</b>				<b>No</b>			
Count	17	4	21	Count	9	5	14
Row Pct	81	19	48.8	Row Pct	64.3	35.7	29.8
Col Pct	45.9	66.7		Col Pct	33.3	25	
Tot Pct	39.5	9.3		Tot Pct	19.1	10.6	
Column	37	6	43	Column	27	20	47
Total %	86	14	100	Total %	57.4	42.6	100

### 3.8 Management training by engineers.

Only 57.4% (by adding the engineer total percentages of **38.3%** and 19.1%) of the responses from contractors were engineers. It tends to reflect the attitude that Consultants see the engineering profession as technically based, and they would only consider bringing in employees with different backgrounds when necessary. While to a contractor engineer, personnel and computer people all form an integral and equally important part of the business. Amongst consultants a little over half the engineers had been on management courses. There are too few non engineers in this group. From a total of 6 non-engineering consultants, two have attended management training courses while 4 did not. Contractors carry two thirds of engineers of whom 67% had attended management courses. Three quarters of non engineers had also attended courses.

### 3.5.2 Companies participating in management training courses.

Looking at tables 3.9, 3.10, 3.11, 3.12, it can be seen (that there are an overall of) 71.1% of firms participate in management training schemes. Also the tables show

the difference in attitudes between consultants and contractors on this matter. While over 86% of contractors make use of such schemes, only 60% of consultants do likewise. As shown earlier it is the senior consultants who do not attend management training schemes, and junior colleagues who are required to attend such courses. But it is very important to point out that the senior consultants manage the companies and yet they seem to be doing less about management training. There are more contractors using management training schemes, with more individuals attending. In this case the figures show that it is the junior contractors that have not yet attended such courses. However from the figures discussed earlier it can be assumed that the contractors who have not attended the courses have not yet reached a stage in their career where such a course would be of importance to them at this point. Tables 3.9 and 3.10, show a break down of these figures by the companies age and tables 3.11 & 3.12 by the companies size.

#### ●Age.

It was difficult to obtain the ages of many companies during the survey and that resulted in a large number of missing cases. There does not appear to be any trend between the age of the company and its use of management training schemes. As can be seen in tables 3.9 and 3.10, the figures are fairly evenly distributed.

	Age				Row Total
	0-23	24-62	63-115	116+	
<b>YES</b>					
Count	3	3	4	3	13
Row Pct	23.1	23.1	30.8	23.1	59.1
Col Pct	60	60	66.7	50	
Tol Pct	13.6	13.6	18.2	13.6	
<b>NO</b>					
Count	2	2	2	3	9
Row Pct	22.2	22.2	22.2	33.3	40.9
Col Pct	40	40	33.3	50	
Tol Pct	9.1	9.1	9.1	13.6	
Column	5	5	6	6	22
Total	22.7	22.7	27.3	27.3	100

### 3.9 Company participation by age (Consultants)

	Age				Row Total
	0-23	24-62	63-115	116+	
<b>YES</b>					
Count	3	7	5	4	19
Row Pct	15.8	36.8	26.3	21.1	86.4
Col Pct	100	77.8	100	80	
Tol Pct	13.6	31.8	22.7	18.2	
<b>NO</b>					
Count		2		1	3
Row Pct		66.7		33.3	13.6
Col Pct		22.2		20	
Tol Pct		9.1		4.5	
Column	3	9	5	5	22
Total	13.6	40.9	22.7	22.7	100

### 3.10 Company participation by age (Contractors)

#### ●Size

For the consultants there seems to be a tendency for the smaller firms to be slightly less involved in management training schemes. It is noticeable that some of the largest consultants do not use the courses while all the largest contractors make use of such courses. Some of the smaller companies tend to find that they do not require such courses. This could be related to the smaller scale of work which

		Turnover £m		Row Total
	0-7		36+	
<b>YES</b>				
Count	8	6	4	18
Row Pct	44.4	33.3	22.2	54.5
Col Pct	61.5	46.2	57.1	
Tol Pct	24.2	18.2	12.1	
<b>NO</b>				
Count	5	7	3	15
Row Pct	33.3	46.7	20	45.5
Col Pct	38.5	53.8	42.9	
Tol Pct	15.2	21.2	9.1	
Column	13	13	7	33
Total	39.4	39.4	21.2	100

### 3.11 Company participation by size (Consultants)

		Turnover £m		Row Total
	0-70	71-350	351+	Total
<b>YES</b>				
Count	5	13	9	27
Row Pct	18.5	48.1	33.3	84.4
Col Pct	62.5	86.7	100	
Tol Pct	15.6	40.6	28.1	
<b>NO</b>				
Count	3	2		5
Row Pct	60	40		15.6
Col Pct	37.5	13.3		
Tol Pct	9.4	6.3		
Column	8	15	9	32
Total	25	46.9	28.1	100

### 3.12 Company participation by size (Contractors)

they carry out. For both consultants and contractors it would be expected that the smaller companies would be less likely to use management training courses as there would be less management to do in a small company. Large companies which deal with major projects would be expected to provide their managers with the required forms of management training courses.

### **3.6 Attitudes to Computing**

This section examines the questions that were asked in the questionnaire which looked into attitudes towards the use of computing within the construction industry (Q13, Q14). Question 13 asked the participants to give their views on the use of computer technology for management purposes. Participants were asked in Q14 if they were comfortable in using computers.

#### **3.6.1 Importance of computers for management**

Although management is not yet that highly regarded by consultants and as such would not be expected to approve of the benefits that technology can offer in different management aspect, the difference between the two groups is small. 58% of consultants feel that computers are essential for management, which is 8% more than for contractors. In the interviews (Scott 1993) one consultant felt that the use of computers in management will not be of much use to the company, but that was the only respondent with an engineering background and over the age of 56, to have made such a statement.

#### **●Age.**

Table 3.13 shows clearly that 93% of consultants feel that computers are either essential or very useful. 89% of contractors in table 3.14 gave similar responses and it is considered to be a high percentage for both consultants and contractors. By examining the distribution of responses from the contractors it can be seen that there were no clear trends across the different age groups.

	Age							Row Total
	26-30	31-35	36-40	41-45	46-50	51-56	56+	
<b>ESSENTIAL</b>								
Count		2	5	8	2	4	4	25
Row Pct		8	20	32	8	16	16	58.1
Col Pct		100	45.5	72.7	50	100	40	
Tol Pct		4.7	11.6	18.6	4.7	9.3	9.3	
<b>V. USEFUL</b>								
Count	1		6	3	1		4	15
Row Pct	6.7		40	20	6.7		26.7	34.9
Col Pct	100		54.5	27.3	25		40	
Tol Pct	2.3		14	7	2.3		9.3	
<b>USEFUL</b>								
Count					1		1	2
Row Pct					50		50	4.7
Col Pct					25		10	
Tol Pct					2.3		2.3	
<b>NOT V. USEFUL</b>								
Count							1	1
Row Pct							100	2.3
Col Pct							10	
Tol Pct							2.3	
Column Total	1 2.3	2 4.7	11 25.6	11 25.6	4 9.3	4 9.3	10 23.3	43 100

3.13 Importance of computers for management by age (Consultants)

●*Engineer*

From table 3.15, it was clear that over 90% of the respondents indicated that computers were essential or very useful for management. Once again, there were no clear distinctions between the different categories.

	Age							Row Total
	26-30	31-35	36-40	41-45	46-50	51-56	56+	
<b>ESSENTIAL</b>								
Count		2	4	4	7	3	3	23
Row Pct		8.7	17.4	17.4	30.4	13	13	50
Col Pct		66.7	50	44.4	50	60	50	
Tol Pct		4.3	8.7	8.7	15.2	6.5	6.5	
<b>V. USEFUL</b>								
Count	1	1	1	5	5	2	3	18
Row Pct	5.6	5.6	5.6	27.8	27.8	11.1	16.7	13.9
Col Pct	100	33.3	12.5	55.6	35.7	40	50	
Tol Pct	2.2	2.2	2.2	10.9	10.9	4.3	6.5	
<b>USEFUL</b>								
Count			3		2			5
Row Pct			60		40			10.9
Col Pct			37.5		14.3			
Tol Pct			6.5		4.3			
<b>NOT V.USEFUL</b>								
Count								
Row Pct								
Col Pct								
Tol Pct								
Column Total	1 2.2	3 6.5	8 17.4	9 19.6	14 30.4	5 10.9	6 13	46 100

### 3.14 Importance of computers for management by age (Contractor)



Consultant					Contractor		
	Engineer	Non	Row		Engineer	Non	Row
		Engineer	Total			Engineer	Total
ESSENTIAL							
Count	20	5	25		13	10	23
Row Pct	80	20	58.1		56.5	43.5	50
Col Pct	54.1	83.3			50	50	
Tol Pct	46.5	11.6			28.3	21.7	
V. USEFUL							
Count	14	1	15		10	8	18
Row Pct	93.3	6.7	34.9		55.6	44.4	39.1
Col Pct	37.8	16.7			38.5	40	
Tol Pct	32.6	2.3			21.7	17.4	
USEFUL							
Count	2		2		3	2	5
Row Pct	100		4.7		60	40	10.9
Col Pct	5.4				11.5	10	
Tol Pct	4.7				6.5	4.3	
NOT V.USEFUL							
Count	1		1				
Row Pct	100		2.3				
Col Pct	2.7						
Tol Pct	2.3						
Column	37	6	43		26	20	46
Total %	86	14	100		56.5	43.5	100

3.15 Importance of computers for management.

### 3.6.2 Importance of computer comfort

Examining the analysis which has been carried out on this question reveals clearly the feeling among the different groups towards using computers. The main reason for asking this question is because technology will not be used to its full potential until the people involved in it and affected by it are completely at ease with this technology. The figures in tables 3.16, 3.17 and 3.18, show that generally the consultants are more comfortable using computers than contractors. Table 3.16

shows that 47% of consultants think that they are very comfortable in using computers and 38% are just comfortable.

	Age							Row
	26-30	31-35	36-40	41-45	46-50	51-55	56+	Total
<b>V.COMFORTABLE</b>								
Count		2	5	7	1		5	20
Row Pct		10	25	35	5		25	47.6
Col Pct		100	45.5	63.6	25		50	
Tol Pct		4.8	11.9	16.7	2.4		11.9	
<b>COMFORTABLE</b>								
Count	1		3	4	3	2	3	16
Row Pct	6.3		18.8	25	18.8	12.5	18.8	38.1
Col Pct	100		27.3	36.4	75	66.7	30	
Tol Pct	2.4		7.1	9.5	7.1	4.8	7.1	
<b>INDIFFERENT</b>								
Count			2			1		3
Row Pct			66.7			33.3		7.1
Col Pct			18.2			33.3		
Tol Pct			4.8			2.4		
<b>UNCOMFORTABLE</b>								
Count			1				2	3
Row Pct			33.3				66.7	7.1
Col Pct			9.1				20	
Tol Pct			2.4				4.8	
Column	1	2	11	11	4	3	10	42
Total	2.4	4.8	26.2	26.2	9.5	7.1	23.8	100

### 3.16 Computer comfort by age (Consultants)

The contractor's figures shown in table 3.17 illustrate that only one third of contractors are completely at ease with computers and yet twice that number consider them essential for engineering. From the table it can be clearly seen that nearly a third of the respondents did not feel comfortable in using computers. This is a major obstacle which may need to be investigated further.

	Age							Row Total
	26-30	31-35	36-40	41-45	46-50	51-56	56+	
<b>V.COMFORTABLE</b>								
Count		3	3	1	5	1	2	15
Row Pct		20	20	6.7	33.3	6.7	13.3	33.3
Col Pct		100	37.5	12.5	35.7	20	33.3	
Tol Pct		6.7	6.7	2.2	11.1	2.2	4.4	
<b>COMFORTABLE</b>								
Count	1		3	5	4	3	1	17
Row Pct	5.9		17.6	29.4	23.5	17.6	5.9	37.8
Col Pct	100		37.5	62.5	28.6	60	16.7	
Tol Pct	2.2		6.7	11.1	8.9	6.7	2.2	
<b>INDIFFERENT</b>								
Count			1		1	1	1	4
Row Pct			25		25	25	25	8.9
Col Pct			12.5		7.1	20	16.7	
Tol Pct			2.2		2.2	2.2	2.2	
<b>UNCOMFORTABLE</b>								
Count				1	4		2	7
Row Pct				14.3	57.1		28.6	15.6
Col Pct				12.5	28.6		33.3	
Tol Pct				2.2	8.9		4.4	
<b>V.UNCOMFORTABLE</b>								
Count			1	1				2
Row Pct			50	50				4.4
Col Pct			12.5	12.5				
Tol Pct			2.3	2.2				
Column	1	3	8	8	14	5	6	45
Total	2.2	6.7	17.8	17.8	31.1	11.1	13.3	100

3.17 Computer comfort by age (Contractors)

Also figures in table 3.16 showed that 14% of consultants are less than comfortable with computers. Although the figure is not very high nevertheless it must be improved in order to take advantage of the new computer technology which could improve managerial skills in many companies, and in the construction industry as a whole. Again table 3.17 shows that contractors are not happy with computers as 29% of them are less than comfortable with using computers, and that is when 87% considered them in the previous question to be either essential or very useful for their work. This is considered to be a relatively high figure and cannot be of great

advantage to the construction industry, as the business world is centred around computer technology and what it can offer to them.

CONSULTANT				CONTRACTOR			
	Engineer	Non Engineer	Row Total		Engineer	Non Engineer	Row Total
<b>V.COMFORTABLE</b>							
Count	16	4	20		9	6	15
Row Pct	80	20	47.6		60	40	33.3
Col Pct	43.2	80			36	30	
Tol Pct	38.1	9.5			20	13.3	
<b>COMFORTABLE</b>							
Count	15	1	16		7	10	17
Row Pct	93.8	6.3	38.1		41.2	58.8	37.8
Col Pct	40.5	20			28	50	
Tol Pct	35.7	2.4			15.6	22.2	
<b>INDIFFERENT</b>							
Count	3		3		3	1	4
Row Pct	100		7.1		75	25	8.9
Col Pct	8.1				12	5	
Tol Pct	7.1				6.7	2.2	
<b>UNCOMFORTABLE</b>							
Count	3		3		6	1	7
Row Pct	100		7.1		85.7	14.3	15.6
Col Pct	8.1				24	5	
Tol Pct	7.1				13.3	2.2	
<b>V.UNCOMFORTABLE</b>							
Count						2	2
Row Pct						100	4.4
Col Pct						10	
Tol Pct						4.4	
Column	37	5	42	Column	25	20	45
Total	88.1	11.9	100	Total	55.6	44.4	100

### 3.18 Computer comfort by engineer

## 3.7 Summary

The number of responses was very high for a questionnaire survey and provided an overall appreciation of management training in the construction industry. When the

responses are broken down into the various factors, the sample becomes small. While some observations may be made about them, caution must be exercised due to the sample size.

The survey revealed that while consultants are lagging behind in management training, the contractors recognised the value of management training and they are making full use of its potential. On the other hand the consultants are more comfortable with computers and this is to their advantage. The contractors showed a disturbing level of discomfort with computers.

The survey revealed that consultants are required to work towards improving their managerial skills through management training courses. Contractors proved to have higher management skills than consultants, but they would be advised to improve their computer familiarity as computers can assist them in achieving some of their training requirement (Scott, Ponniah, Saoud 1994). Polson (1988) suggested that trainees must be able to use the technology it self in order to learn. Computing skills are now considered as a basic literacy skill by the construction industry. As some of these skills might be developed through Intelligent computer aided learning (ICAL) or tutor expert systems. It is appreciated that many of the management skills such as social skills, interpersonal skills or leadership skills can not effectively be carried out with such systems. The following chapter examines different aspects of expert systems as a tool that can be used in construction management training.

# Chapter 4 Expert Systems

## 4.1 Introduction

Artificial intelligence (AI) is the computer-based solution of complex problems through the application of processes that are analogous to the human reasoning process. Rolston (1989) and Terry (1991) stated that the field of Artificial Intelligence evolved as a sub field of computer science by individuals concerned with symbolic processing and human problem solving.

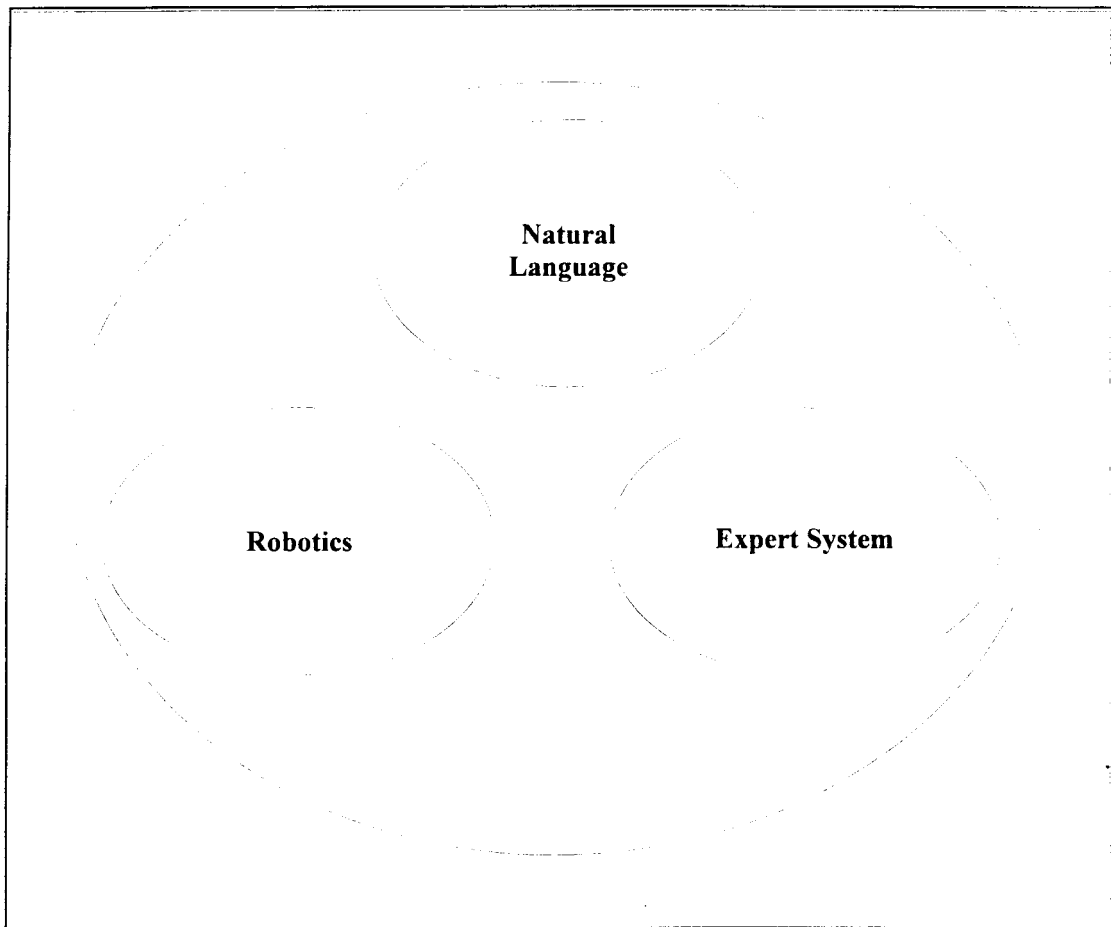


Figure (4.1) Some areas of artificial intelligence  
Adopted from: Expert Systems "Principle and Programming", Lotfi Zadeh, (1989)

Figure 4.1 shows that the field of **AI** has many areas of interest. of which natural languages (developing programs that read, speak or understand conversational language), robotics (developing smart robots that recognise objects), and expert/knowledge systems (replicating the thought process of experts in different fields of knowledge) are the most notable. The area of expert systems is a very successful approximate solution to the classic **AI** problem of programming intelligence and the following sections focus on expert systems.

## **4.2 Expert Systems**

An expert system tool can look the same as a conventional program to the user. An expert system and a conventional programme can both present to the user a series of options on the screen in the form of questions, and answers, which would be given depending on the user responses to those answers (Allwood 1986). However there are a number of advantages of expert systems over conventional programs :

- ( a ) Ability to handle qualitative information, as expert systems usually deal with large amounts of knowledge;
- ( b ) Coping with uncertain, unreliable or even missing data, also expert systems have the ability to deal with unexpected input;
- ( c ) Expert systems are not confined by rigid mathematical or analog schemes and can handle factual or heuristic knowledge;
- ( d ) The knowledge base can be continuously augmented as necessary with accumulating experience.

Maher (1987) explained that expert systems, or knowledge-based expert systems, are interactive computer programs with built in judgement, experience, rules of thumb,

intuition, and other expertise to provide knowledgeable advice and solutions on different subjects. Minkarah (1989) provides us with a more specific definition of expert systems as -- a computer program that uses expert knowledge to reach a level of performance akin to that achievable by highly skilled experts". Therefore expert systems are designed to address complex problems and to explain the reasoning process, in which the knowledge is represented symbolically rather than numerically. Wijesundera (1986) describes further the implementation of an expert system as a simulation for a consultation process between an expert of a particular field and a non expert. Typically, the non-expert is the end user and the computer model is the expert.

#### **4.2.1 Principles of expert systems**

The principles of a knowledge-based expert system is described in figure **4.2**. Most expert systems operate through the user supplying facts and different information to the expert system and in return the user obtains expert advice. The expert system consists of two main internal parts. The knowledge-base which will contain the knowledge that helps the inference engine in drawing the related conclusions. These conclusions are considered to be the expert system's responses to the user's queries for expertise (Zadeh 1989).



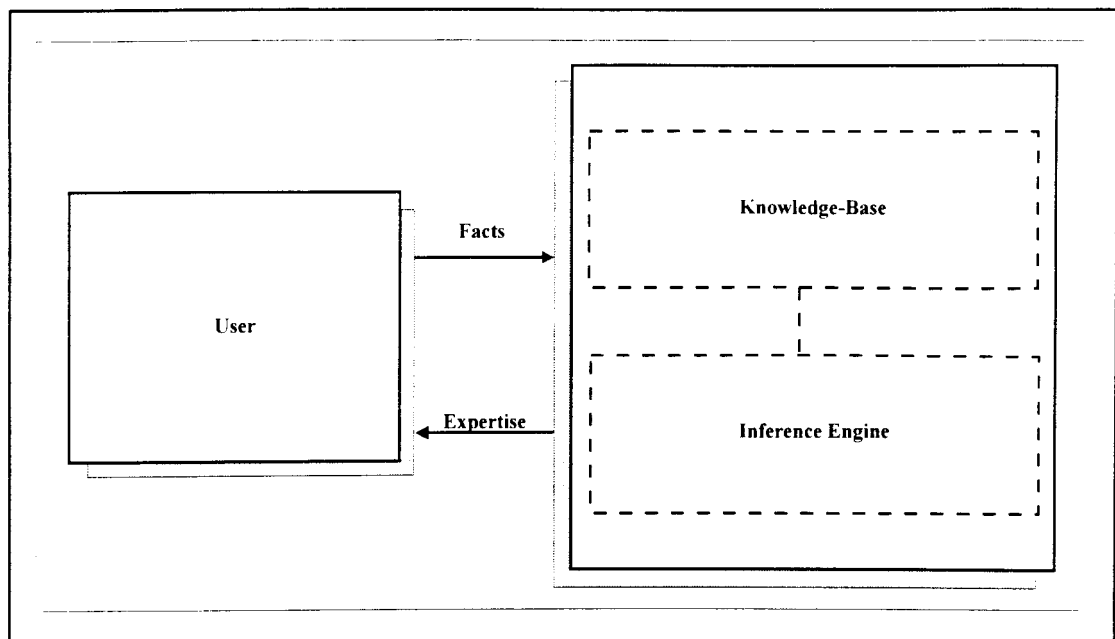


Figure 4.2 Basic concept of an expert system function

Source: Expert Systems "Principle and Programming", Lotfi Zadeh, (1989)

Another vital factor to understand in any expert system, is the relationship between the problem domain and the knowledge domain. Giarratano and Riley (1989) discuss this relationship as follows: all knowledge domain is usually presented within the problem domain. As can be seen from figure 4.3 the section outside the knowledge domain symbolises an area in which there is in adequate knowledge

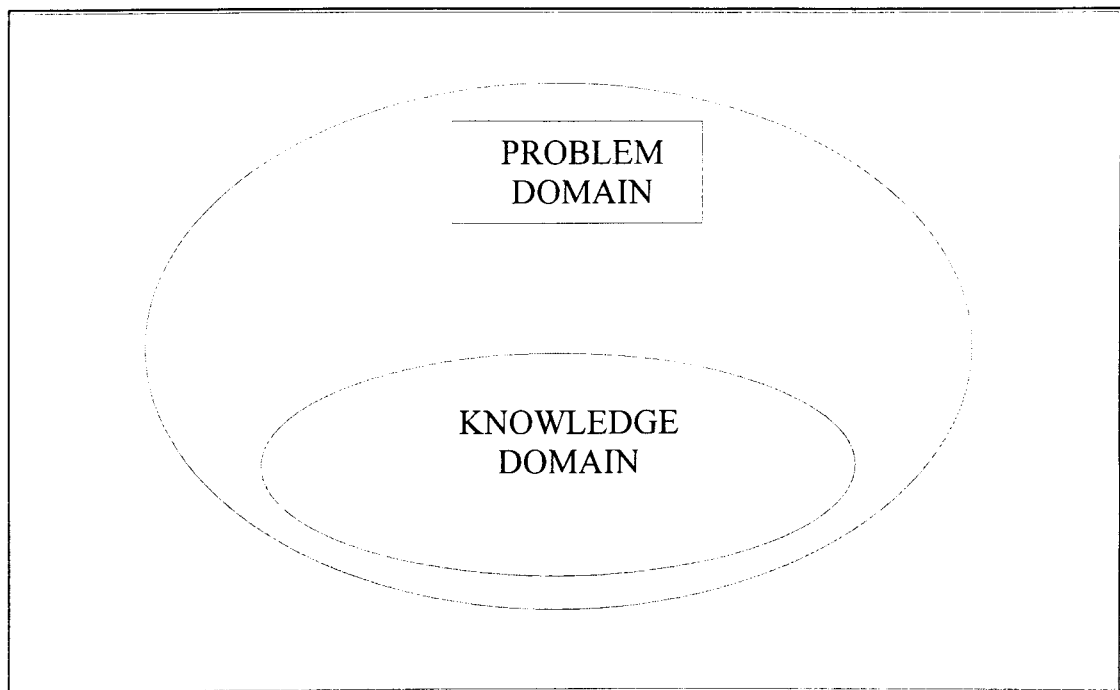


Figure 4.3 A possible problem and knowledge domain relationship  
Source: Expert Systems "Principle and Programming", Lotfi Zadeh, (1989)

about the problem. The knowledge acquired in most expert systems are usually obtained from published materials, project records and directly from experts in the field that the expert system is being built.

#### 4.2.2 Elements of expert systems

The principles of expert systems may be elaborated further by considering the elements that form the system. They are : (Warzawski 1989)

- ( a ) A knowledge base of facts (standards, physical attributes, economic values, etc.), and action rules in the problem domain. The data in the knowledge base may be represented in the following fashions, all applicable in the construction industry :
- ( i ) Relational: where different sources of structured knowledge can be inter-linked, so information can be shared. **An** example of this is when dealing with lists of workers, suppliers, clients, subcontractors, etc. and their pertinent attributes.

( ii ) Hierarchical: an expert system can present data in a well structured order. This is considered to be useful when describing workers or materials composition of a particular project.

( iii ) Network: the data can be structured in the form of rules which allow freedom in problem solving. This means that the expert system does not have to follow a particular structure when matching the rules with the relevant knowledge. An example of this is when relating to technological construction alternatives or activities; it means that the right solution can be reached by the expert system directly. The action rules are either normative i.e. embodied in standards and codes, or heuristic and based on experts' experience, judgement and rule of thumb. The knowledge base of the system may be updated or modified, depending on the latest information available. Hence rules can be upgraded if the knowledge in any given field advances.

( b ) The Context (global data base or working memory) which stores the data about the specific problem under consideration, and keeps track of the current state of its solution.

( c ) An Inference Engine (inference procedure) which activates the pertinent information or rules from the knowledge base on the data, within the context, and for the solution of the problem. The inference engine usually employs a mechanism that matches information in the context with pertinent action rules in the knowledge base, and if several rules apply, it selects the most appropriate course. It then implements the selected action. Terry (1991) categorised the expert systems solution derivation according to the links or chains that matches the rules in the knowledge base with the facts presented in the working memory to arrive at a conclusion.

The categories are :

( i ) Forward Chaining, where the inference engine starts with facts and matches them to the conditions of a rule. If the condition is satisfied, the rule's conclusions are used to prove additional or further rules. This continues until sufficient rules and facts are established to make a conclusion.

( ii ) Backward Chaining, in which the inference engine processes rules by examining first the rule's conclusion and then its premise. The inference engine selects a rule with a conclusion that directly solves the problem. It then tries to determine whether the rule's premise is true or false. If the premise is false the engine selects another rule. If the premise is neither true or false (not enough rules or facts have been examined to determine this), the engine selects another rule with a conclusion that could solve the premise.

Jackson (1986) also traced the computer-based problem solving back to early attempts to program computers to play games and prove theorems. He calls this period "the classical period" and the idea is called 'state space search'. The simplest form of state space search is called 'generate and test', with two types: breadth-first search and depth-first search. In breadth-first search, one searches layer by layer through successive levels of search space, where as in depth-first search one pursues a single path at a time, returning to the initial point of the problem to pick another path only if the current path fails.

### **4.2.3 Expert system architecture**

In order to get an understanding of how expert systems function, it is appropriate to look at the expert system architecture and examine the different components that contribute to presenting the expert's knowledge in such a system. The architecture of an expert system is difficult to define, as languages and system build up tools can vary in their development stage and are therefore illustrated through examples. An example of an expert system architecture is shown below in figure 4.4. The example illustrates all different components of the expert system architecture. The basic architecture shows a separation of domain knowledge, control knowledge, and knowledge which deals with the problem in hand which needs to be solved. This highlights three important components of an expert system which are: the knowledge base, the context, and the inference mechanism. Other components that can be part of the expert system architecture are, user interface and an explanation facility. Finally a knowledge acquisition facility is also considered to be useful in many expert systems. Maher (1987) explains further the expert system components as:

( a ) Knowledge Base: The knowledge base is the component of an expert system that contains the facts about the subject which is being dealt with. The facts could be presented in the form of rules and sub rules. For example the potential contents of a knowledge base for project tendering would include related facts about the project location, size and complexity of project, contingency plans available, etc. Since knowledge is continually changing and expanding it is considered to be important that the knowledge base is clearly structured and can easily be modified if required to do so.

( b ) Context : The context is the component which is responsible for providing the information on the problem which is being solved. As the problem solving procedure continues the context will expand to provide more information on the problem in order to continue to solve it.

( c ) Inference mechanism : The inference mechanism is the part of the expert system which contains the control information. It does that by using the knowledge base to modify and expand the context. The inference mechanism's main task is to relate rules or sub rules to the facts and execute the most appropriate rules that can satisfy the facts.

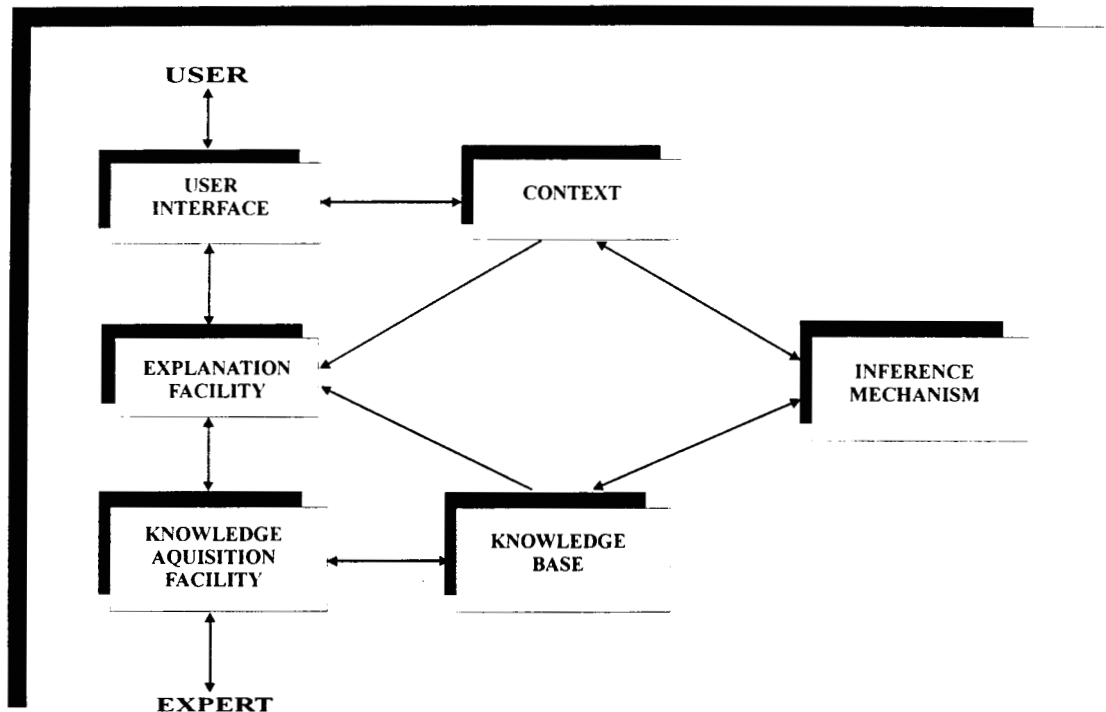


Figure 4.4 Architecture of An Expert System  
(Source : Mary Lou Maher, expert system for civil engineers )

( d ) Explanation facility : The explanation facility in an expert system varies from a trace of execution to the ability to give the user the reasons behind reaching a

particular solution. It will demonstrate this by showing the user the path that was followed in order to reach a certain conclusion.

( e ) Knowledge acquisition : The knowledge acquisition facility in an expert system is the component which is responsible for entering the knowledge to the knowledge base. This facility acts as an editor, and knowledge is entered directly in a form acceptable to the way in which the expert system was structured. Editing the knowledge can be carried out in two ways: either the knowledge engineer uses a screen editor to create and modify a file of rules, or the editor is itself an expert system, and that would be used in building more complex expert systems.

( f ) User interface : The expert system user interface is the component which is responsible for the communication mechanism between the user and the system. In addition to being highly interactive, an expert system interface requires a transparency of dialogue, whereby some form of an explanation facility indicates the inference process that is being used.

#### **4.2.3.1 Architectural variations**

Two of the most commonly used variations on the basic architecture are the blackboard model and the production system model. The two models will be looked at in more detail below.

( a ) Blackboard model : As can be seen in figure 4.5, the blackboard model is based upon the separation of the knowledge base into knowledge sources. It also provides a means of communication between knowledge sources. The circles and lines

represent the communication between knowledge sources and the current state of the problem solved which takes place within the blackboard (Maher 1987).

Blackboard architectures are explicitly designed to permit multiple knowledge sources to address a problem simultaneously. Provided its preconditions are satisfied, each knowledge source can post recommendations for action to a shared data termed a "blackboard" (Tommelein 1987).

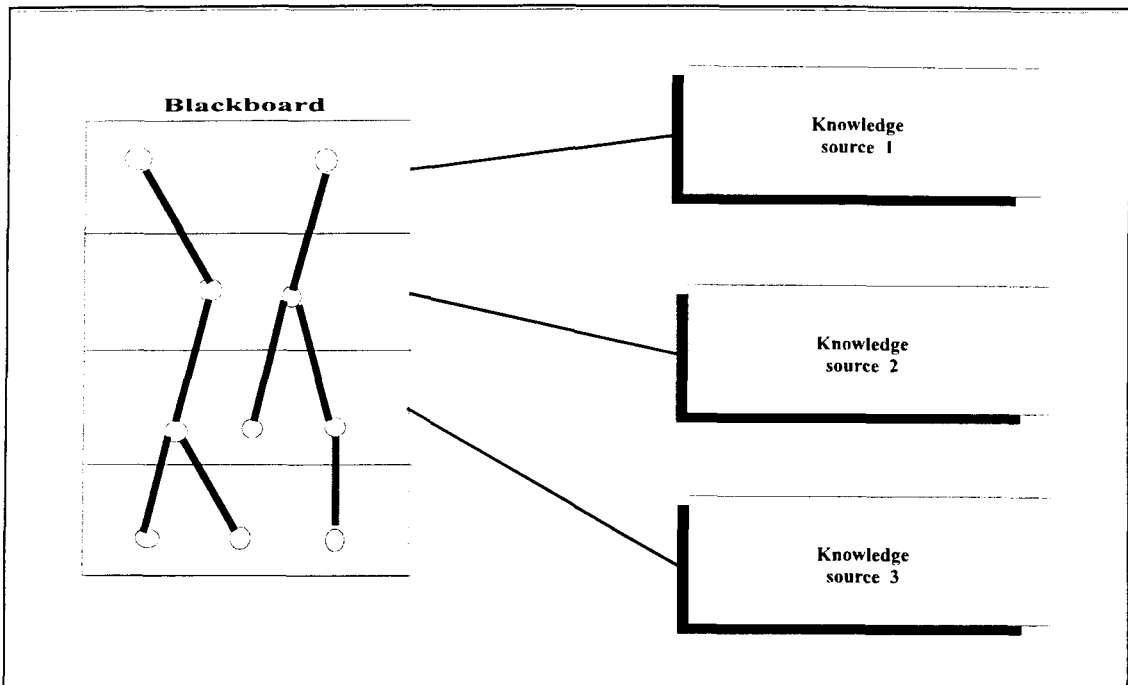


Figure 4.5 Black board Model

(Source Mary Lou Maher, Expert systems for civil engineers: Technology and application, (1987)

#### ( b ) Production system model

The production system model classifies the knowledge base as a series of rules, usually known as production memory. Normally the rules would be developed by the expert, and there would be no need to specify them in any certain order. The context in a production system model is known as the working memory. The inference mechanism in such a system is expected to identify the production rules



that would be executed and perform the selection operation to choose the most suitable rule to solve the problem. The production system model is illustrated in figure 4.6 below.

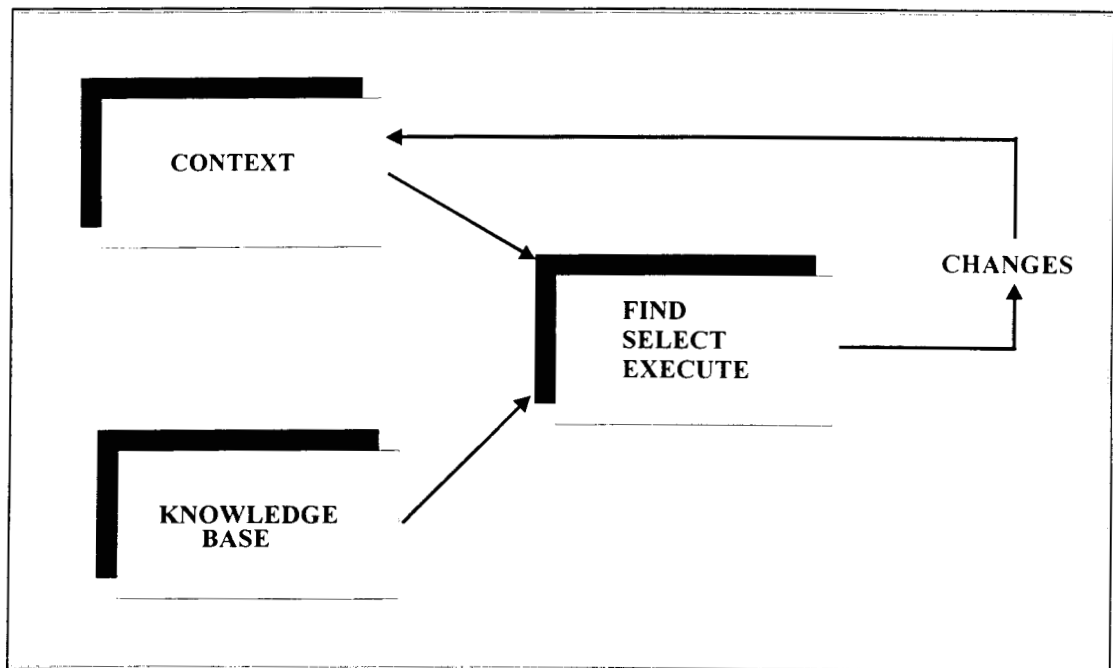


Figure 4.6 Production system model.

(Source Mary Lou Maher, Expert systems for civil engineers: Technology and application, (1987))

#### 4.2.4 Expert systems and other algorithmic programs.

The important features of expert systems when compared to other mathematical models are pointed out by Jackson (1986) as:

( a ) Expert systems are not confined by rigid mathematical or analogue schemes and can handle factual or heuristic knowledge;

( b ) The knowledge base can be continuously augmented as necessary with accumulating experience. As the knowledge advances the expert system can be easily upgraded to cope with the changes in technology;

( c ) Ability to handle qualitative information. This can be clearly experienced if the system to be built is expected to contain a large amount of information as for example in many management areas;

( d ) Coping with uncertain, unreliable or even missing data. Dealing with uncertainty in data and inference is a feature of expert systems. When pieces of the knowledge base and context are less than certain, then a new level of complexity is introduced into expert systems. Some expert system shells have adopted Bayesian probability in coping with uncertainties within the knowledge base;

( e ) The reflection of decision patterns of the users. This is a function which is some times referred to as an explanation facility. It explains the reasons behind giving a certain conclusion that has been reached by the expert system.

#### **4.2.5 Integration of expert systems with other fields**

There are two fields of computer science that will enhance the quality of expert systems if they are incorporated during the building of the system.

( i ) Computer aided design (CAD)

Morad (1991) describes KNOW-PLAN, a planning system that integrates computer aided design (CAD) technology with artificial intelligence (AI) technology to

simulate the process of constructing a facility interactively and graphically on the screen of a graphics Workstation.

Morad (1991) stresses the incorporation of CAD with expert systems due to the following advantages in CAD :

- ( i ) It can provide object definition data represented by 3-D computer model.
- ( ii ) It can provide a simulation capability to model the construction process graphically.
- ( iii ) It can provide visual communication between the user and the computer.

Reddy (1986) argues that knowledge based expert systems provide a prescription, while a simulation model provides a prediction. That means that if a goal is given then a knowledge based expert system suggests a course of action, while a simulation model predicts the consequences of a selected course of action under some experimental conditions.

Touran (1990) developed SIMEX, a prototype system that allows the user to choose a suitable earth-moving system, simulate the operation and evaluate cost and production performance. The developed prototype has shown a great potential for simulation/expert system integration.

#### **4.2.6 Knowledge Representation**

Knowledge representation involves finding the best method to use to present the domain knowledge as data structure. This is considered to be an important step so the knowledge can be efficiently accessed for the problem solving task.

#### **4.2.6.1 Rule Based**

Most rule-based systems (RBS) can be classified as production systems (PS). The main element in this system is that the domain knowledge is represented in modular rules. Production rules are the most comprehensive form of knowledge representation which are based on condition-dependent action. It has become apparent that experts can best formulate their knowledge in the form of 'If .....Then.....' rules. This is probably the reason why most expert systems today, at least the most successful ones, are based on production rules (Nebendahl 1988). An example of production rule languages is OPS5.

Trimble (1989) gives the following example for production rules:-

IF the project is largely repetitive  
AND the successive items are approximately identical in work content  
AND the user is familiar with "line of balance" technique  
THEN the user should use "line of balance" for the planning and control of his project.

Jackson (1986) cites the fact that representing knowledge as an unordered and unstructured set of rules has certain disadvantages which probably outweigh the often stated advantage that one can easily add another rule to a present set.

#### **4.2.6.2 Object Oriented**

Object oriented representation is about grouping objects by organising them into classes. One obvious advantage of classification is that it eases memory load as only the characteristics would be considered and not each individual object. Also it

defines relationship between those classes. The fundamental organising principle in such systems is the packaging of both data and procedures into structures related by some form of inheritance mechanisms. The process of expanding a knowledge-based system is one of incremental programming; you simply tell the system about more objects, and as long as they are placed at the right point in the hierarchy, inheritance would always do the right thing. One of the object-centred languages is FLAVORS which is embedded in ZETALISP (Jackson 1986). Examples of objects in expert system shells can be viewed in Alshaw (1989).

Jackson (1986) states that one of the disadvantages of object-oriented systems is that many systems do not incorporate any distinction between "essential" properties (those that an individual must possess in order to be considered an instance of a concept) and "accidental" properties (those that all the instances of a concept just happen to possess). Instead, instances usually inherit 'typical' properties, which are susceptible to cancellation or alteration anywhere in the hierarchy. This makes it impossible to express universal truths, or even to construct composite concepts out of simpler conceptual units, in a reliable way.

#### **4.2.6.3 Logical-Based**

A logic-based representation is one in which knowledge about the world is represented as assertions in logic, usually first order predicate logic or a variant thereof. Logic based languages allow quantified statements and other well defined formulas as assertions (Buchanan 1982).

Jackson (1986) points out that systems like MYCIN, which lack the power of first order logic, are unable to express simple rules like 'don't bother to prescribe a drug

that has already been tried on a patient'. In rule interpreters like OPS5, if one wants to express such a rule, one has to include such a statement in every instance related to prescribing a drug.

A logic database for representing knowledge about some domain is typically a set of clauses, ordered so that special cases occur first. An example for logic programming languages is PROLOG. Logic programming techniques for expert systems are by no means as tried and tested as techniques based on rules and frames but it can be observed from the attempts to implement it that it does not automatically abolish all pitfalls associated with frames and rules. It needs an experienced programmer to structure rules and data according to a logic programming language.

### **4.3 Expert system shells**

There are several approaches to building expert systems in terms of what kind of tools to use. These tools are normally classified as : languages, environments or shells, while some tools may fall between any two categories (Guttormsen, 1987).

( a ) Languages can be either special purpose languages for symbolic programming, such as LISP or PROLOG, or a conventional one, such as PASCAL or C

( b ) Environments contain various types of knowledge representation, inference mechanisms, user interface and development aids. These tools also give access to the underlying language the environment is written in. This enables the developer to incorporate special tasks. KEE, ART and EDSS are all environments.

( c ) Shells provide a more specific set of knowledge representation languages and inference mechanisms, geared to handle a particular class of problems.

Both shells and environments differ from the languages in the fact that they already contain control mechanisms that determine how they reach conclusions.

#### **4.3.1 Types and features of expert system shells**

Terry (1991) listed the following features in typical shells :

( a ) Built-in inference engine with choice of chaining methodology. In some shells mixed chaining is considered to be a useful feature in some shells , as it helps the knowledge engineer to either put constraints at the start of the rules or at the end. depending on what is required to solve a problem.

( b ) Menus and prompts for development and testing. Menus must be easy and clear to use and contain all the functions needed to build the required expert system. It is important that the knowledge engineer becomes familiar with the shell menus and prompts in order to find out whether it will be able to perform the job in hand.

( c ) Debugging and value-checking aids. This function will deal with the ability of the shell in the debugging of any input errors, which could be contained in the information and values.

( d ) Consistency checking This function will check that the rules do not contradict each other, as this could lead to false assumptions or wrong conclusions.

( e ) Rule - prioritise capabilities. When solving a particular problem a group of rules which relate more closely to the problem will be considered first. By matching the rules to the problem in hand the correct rule to solve the problem will be chosen.

( f ) Interface with other operating systems and software. The shell must have all the required interfaces to assist in building the expert system. These interfaces can either be supplied as part of the shell or it must have the ability to communicate with other software, whether by direct access or by exporting and importing functions. The shell should also have the ability to create and display graphics or interface with graphics software programs.

( g ) Mechanism for handling input and calculation of uncertainties. This function will allow the shell to deal with missing or uncompleted data which could be inserted by the user in the form of input.

( i ) Explanation facilities. This function will allow the user to find out why and how the system arrives at its decisions, with the sequence of rules involved.

#### **4.3.2 Comparison with other development tools.**

In the survey conducted by Mohan (1990), **24** out of the 37 expert systems developed were developed on IBM PC class of microcomputers. **18** out of the 37 expert systems were developed using expert system shells (that is nearly 50%), 7 were developed using expert systems environments, 7 using artificial languages and 5 using other languages. That indicates the popularity of shells as a tool in developing expert systems.

Guttorsman (1987) divided shells into the following types :



( a ) Induction tools

These shells generate rules based on a number of examples given by the developer. The shell then applies certain algorithms to the rules to determine the order the system will take when putting questions to the user. These tools are useful only when the task is simple and well structured. SUPEREXPERT is a typical example of this class.

( b ) Simple rule-based tool

If...Then rules are used to represent knowledge in the knowledge base. The main weakness of these shells is the inability to sub-divide into various sets that can be arranged into a hierarchy. Typical applications are small rule bases containing from 50 to 200 rules.

( c ) Object oriented tools

These tools represent the knowledge as objects which can be given certain values. An object may contain facts, rules or pointers to other objects. The problem must be of a certain complexity to justify the use of complex object-oriented shells. LEONARDO is an example of this class.

( d ) Logical tools

These tools use Horn clauses and resolution strategies derived from predicate calculus. They are useful when dealing with very complex problems in terms of logic.

( e ) Structured rule-based tools

These shells also use IF...THEN rules but with the facility of arranging rules in a hierarchy. These systems are useful where a large number of rules are involved. CRYSTAL is a typical example of structured rule-based tools.

#### **4.4 Expert System and the construction industry**

The features that distinguish expert systems from other algorithmic programs are not enough on their own to set expert systems as a potential computational stream to be implemented in the construction industry. The construction industry's environment itself should possess certain features that show the need for expert systems - like technology for improving construction's quality and productivity.

Levitt (1985, 1987) points out that the following features of the construction industry show this need:

( a ) Unlike manufacturing, construction is non-repetitive, where each project is different in design, layout, materials used, construction methods, time, crews, weather and management. Ready algorithmic solutions are therefore not applicable to the day-to-day construction problems.

( b ) Construction environments are full of uncertainties in respect of labour, equipment, productivity, market forces and variations in weather. Expert systems can handle these uncertainties while algorithmic programs cannot.

( c ) The non-availability of complete knowledge in the field of construction management and engineering being encoded in text books. The industry runs on conventional knowledge and experience based judgement.

( d ) Many decisions in the industry are made on the spot so that the construction process is not interrupted due to time limitations on making a detailed analysis of all the influencing factors. Expert systems can provide decisions in such situations.

( e ) Many construction professionals and managers lack the necessary knowledge of computer science to be able to use and update algorithmic computer programs.

( f ) The construction industry is rich in experts who have successfully completed several projects thus gaining domain knowledge about the industry which can be used in expert systems.

#### **4.4.1 Areas suitable for expert systems**

Many researchers have worked to identify the most suitable areas for expert system implementation in the field of project management generally and the field of construction management specially. Among these areas identified by Mohan (1990), Aitcheson (1990), Warszawski (1985), Robinson (1989), Minkarah (1989), Hamilton (1987), McGartland (1985) and Benjamin (1990) are the following:-

##### **( a ) Estimating**

The expert system in this case will ask the user to provide it with the required data to any particular project and compare it against the expert knowledge and historical data in the expert system. The expert system may then produce offer prices in tenders or

negotiated contracts, tender preliminary estimates and aid in evaluation of design or construction alternatives.

( b ) Design of construction methods

Expert systems can be used in various topics in design of construction methods which can include configuration of crews, choice of construction methods. man-machine trade off, choice of transportation mode for the movement of the materials, and methods of joining various components in modular construction.

( c ) Site planning

The expert system in this situation would be able to determine the location of equipment for carrying out a certain job, and also location of materials and support facilities at a given construction site.

( d ) Project planning, scheduling and control

Some of the tasks that would be expected from an expert system in this area will include: providing the user with information on time-cost estimates of activities; generation of construction schedules; and critical path analysis and resource allocation.

( d ) Construction quality control

Tasks for expert system in construction quality control will include sample size, sample location, time of sampling and permissible tolerances.

( e ) Human resource management

An example of human resource management expert system in this area would be the selection and recruitment expert system. As expert's knowledge on the requirement

and the standards for recruitment can be inserted in the knowledge base and when choosing an applicant for a particular job, the applicant will have to satisfy all the rules within the knowledge base in order to be selected for the job. Also expert systems can be used in project and company organisation structures, personnel management, labour relations and productivity improvement techniques.

( f ) Operational problems in constructed facilities

Operational problems can accrue in constructed facilities. Expert systems can solve facilities problems by giving causes and remedial actions for functional failures such as leaking, poor ventilation, and temperature control. Also it can provide causes and remedial actions for structural failures such as foundation settlement and cracking.

( g ) Training and development

An excellent tool for inexperienced project staff to improve their project management skills and techniques. It can also form an important part of the training function and can be used as an aid to training programs. The advantage of this would be that the trainee can have an access to the expert's knowledge virtually at any time as expert systems can be mounted on desk top PCs. This will give the opportunity to trainees to improve on their skills by going through the training expert system within the work environment. Some other areas include constructability evaluation, material management and legal issues.

#### **4.4.2 Examples of the use of expert systems in construction**

There is a large number of expert systems in the industry whether listed in the above survey or still under development.

The following is a sample of these systems:-

( a ) BIDEX (BIDding Expert) (Minkarah 1989) - is a system in its development stage that would be used by construction contractors to make bid decisions. It is developed using EXSYS (an expert system shell). The bidding decision-making process is a two-stage process. The first stage involves the decision whether or not to bid, and the second stage involves the selection of mark up. Factors such as type of job, owner, location, size of job, current work load and strength of the firm are important for the bid/no-bid decision, while degree of hazard, degree of difficulty, uncertainty in the estimate, risk in investment and reliability of sub-contractors are important for the present mark up decision.

( b ) PC Pile (Yeh 1991)- PC Pile is an expert system for diagnosing the damage of pre-stressed concrete piles during construction. The system is built using Turbo Prolog programming language. The knowledge in this system is presented in a rule knowledge base using deductive inference mechanism, but because of the insufficient expertise of experts, some of the causes in a diagnosis problem could not be clarified by asking the experts about further symptoms. Thus the system uses another knowledge base, the case knowledge base, which implements the analogical inference mechanism to arrive at conclusions. The system uses fuzzy logic efficiently to deduce the damage caused in pre-stressed concrete piles. The structure

of the system is novel in two aspects: case base knowledge representation and the analogical inference technique.

( c ) Expert advisor in the planning and scheduling of building construction projects (Benjamin, 1990) - This system is a smaller complementary part of the work done by Carnegie Mellon University ( Construction Planex) and MIT (GOST) in the field of applying expert systems in construction planning and scheduling. The tool used by Benjamin (1990) is M1 shell- a rule based shell. In this sub-based system, the knowledge base consists of about 100 production rules, 74 facts that describe the different activities representing the project breakdown, 22 facts that describe the hierarchy of activities, and 50 facts that describe the procedure relationships among activities. The system was tested as a tool for improving inexperienced construction project schedulers. The ability of the system to explain, assist and advise the inexperienced construction schedulers was thereby demonstrated where the average performance time of the inexperienced subject the computer system was comparable to that of the subject with a civil engineering background.

( d ) Expert system for the Norwegian Building Regulations, (Mitusch, 1989) - The objective of the expert system is to enable the analysis of a building with respect to the fire requirement of the Norwegian Building Regulations. The knowledge base which contains nearly 250 rules is developed with the expert system shell "expert object" from Neuron Data using a Macintosh II. It is also available for IBM PC/AT and compatibles and the Apollo, Sun, HP and VAX Workstations. The system is linked to Hyper Card which is a combination of graphics program, data base and software development tool. Mitusch (1989) suggests that this system offers good user interface in a time most applications built with expert systems shells don't. He

insists that in the future the user groups will hardly accept a bad interface and insisting on having larger control and flexibility in their programs.

#### **4.5 Summary**

Expert systems is an application area of artificial intelligence, which in turn is a branch of computer science. The field of expert systems is concerned with capturing the knowledge and experience of experts in a certain field and feeding it to the computer, thus creating what is called knowledge based expert systems.

The choice of the development tool is a function of many variables (time, programming skills, the problem under consideration itself, etc.). So it is important to choose the right tool to achieve the anticipated results by utilising the available resources. If shells are to be considered as the tool to develop the required expert system then the available shell must be assessed against a set of criteria in order to select the most appropriate shell that meets the needs of the expert system tool. Expert systems have the potential to increase the effectiveness and efficiency of construction management tasks (Minkarah 1989). At the same time one must neither forget the complexity of expert systems development nor the cost of this operation, which Robinson (1986) estimated as \$1,000,000 to \$2,000,000 and employing from 10 - 25 man-years.



## **Chapter 5 Methodology**

### **5.1 Introduction**

The objective of the research was to ascertain the viability of the use of expert systems as an aid in the training of individuals within the construction industry. Within this objective there were a number of identified aims which were; identifying the need for training and the attitudes to computing, developing an expert system on selected topics, and evaluating the elements in the use of the expert systems. These aims categorised the research into three main areas; a questionnaire survey of the construction industry as to its attitude to management training and computing, development of a management training based expert system, and finally evaluating the expert system.

The survey which was carried at the beginning of this research revealed that not only more training is needed but more importantly training at the appropriate time was needed for improving the training and development function within the construction industry. The findings of the survey agreed with those that were revealed by the literature review in chapter 2, as it also showed that more effort was needed to improve the role of management training within the construction industry.

The second part of the research dealt with the development of a management training model, to be used as an aid to a construction management training program. A requirement for the development of such a model needed a literature survey on aspects of expert systems, and a period of experimentation and familiarisation with the chosen expert system shell, CRYSTAL. Prototypes were developed in order to acquire the operating knowledge of CRYSTAL.

Finally an evaluation of the expert system was conducted in order to receive feed back from users. Figure 5.1 presents clearly the way in which the research was conducted from its initial stages of collecting background information on the research subjects to the final stage of data evaluation and conclusions.

## **5.2 Choice of appropriate shell**

As described in chapter 4 of this thesis an expert system shell is a program used to build an expert system. Just as a word processor is a tool for producing a letter or a report, a shell is instrumental in developing an expert system. A typical expert system shell consists of some form of knowledge representation scheme and a built-in inference mechanism. In addition, the shell often contains facilities for producing clear interfaces for the use of the application. But it must be noted that this type of shell gives no assistance in eliciting and organising the knowledge. For this, a knowledge acquisition tool would be required.

Guttorsman (1987) compared three system shells: SUPEREXPERT from Intelligent Terminals Ltd, LEONARDO1 from Creative Logic Ltd and CRYSTAL4 from Intelligent Environments Ltd. He used the 3 shells to build CAR BASE, as a prediction/diagnosis system for fault finding in car engines. Guttorsman also used LEONARDO and CRYSTAL to build PC BASE as a design support system to configure components of microcomputers. In the analysis of the capabilities of the shells Guttorsman found that although SUPEREXPERT is fast and easy to use, it was too restricted for building CARBASE and PCBASE. Guttorsman concluded that LEONARDO and CRYSTAL are more flexible and faster for development of the knowledge base.

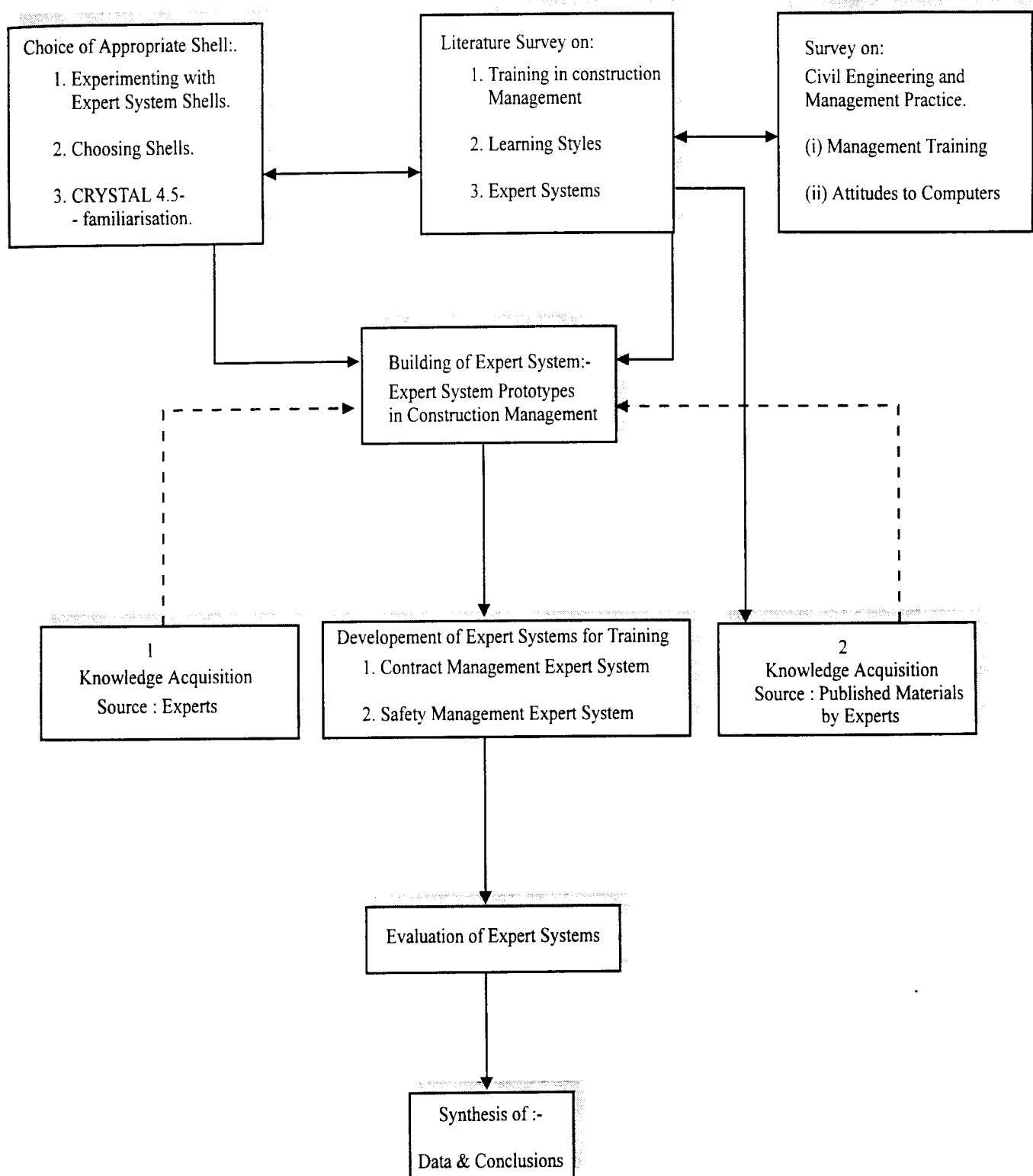


Figure 5.1 Out Line of Research Methodology

An important feature in expert systems shells, which is their external interfaces, was discussed in an article by Lydiard (1989), which contained the examination of features for four shells, among them, CRYSTAL version 3.20 and LEONARDO level 3 version 3.18.

He commented that neither LEONARDO nor CRYSTAL have product interfaces as good as Xi PLUS. For example, where large user programs and other software products such as spreadsheets, databases and word processor, can be called directly from a knowledge base. He also commented that Intelligent Environments has developed a range of interfaces for CRYSTAL, all of which must be purchased in addition to the main package.

When we are faced with the decision of choosing a tool to develop an expert system to solve a particular problem, we have to study both the problem under consideration and available resources, such as time, finance, programming experience and expert systems building experience. A trade off had to be made between the built facilities of the shells, and flexibility of environment and languages, to reach an optimum solution for this resources allocation problem.

The possibility of choosing an induction tool like SUPEREXPERT was eliminated due to its inadequacy in handling large and complex problems. The available shells were therefore CRYSTAL Version 4.5, a structural rule-based tool, and LEONARDO level 3 which is an object oriented tool. After working with the two shells, and becoming familiar with their capability through different prototype applications developed using them, studying their manuals and assessing their performance against the criteria mentioned in chapter 4, it was decided to choose CRYSTAL, in this research to develop the two construction management tools.

### **5.3 Literature Survey**

The purpose of the literature survey was to review existing knowledge and to get a link between human resource management (training management) and expert systems, which could be used as an aid/tool to the training function. The literature survey involved two topics;

- ( i ) Training management, focusing on the construction industry and present views on the topic.
- ( ii ) Expert system as a tool that could contribute to the training quality provided in contract management and health and safety management.

The two topics of the research were described earlier in chapters 2 and 4.

### **5.4 Choice of Safety and Contract Management**

Research was carried out by Ponniah (1992) in assessing the training needs within the construction industry. This was an investigation into industry's, i.e. consultant's and contractor's and the Institution's, views on what type of training and skills are required within the construction industry. The research revealed that there is still a great demand within the construction industry for more training in many aspects of safety and contract management. Hence safety management and contract management were chosen as the two main areas for the training knowledge base. The research (Ponniah, 1992) has highlighted other areas that could be investigated, such as quality assurance and risk analysis.

## **5.5 Building of expert system**

The actual procedure of using CRYSTAL to build the two expert systems will be discussed in greater depth in chapter 6. In the following sections further discussion will be included on method of knowledge acquisition required to create the knowledge based expert systems.

In order to build a comprehensive expert system. the following four steps were recommended by Terry (1991);

- ( a ) Identify the problem and detect if there is a need for the application. Determine if expert systems are a viable solution to the problem.
- ( b ) Select an expert system development tool. Whether a programming language, an environment or a shell according to the flexibility, power. speed of execution needed and the ability of the developer (programmer) himself.
- ( c ) Create a prototype. Demonstrate the credibility and feasibility of the prototype.
- ( d ) Refine and extend the prototype. Customise the user interface.

## **5.6 Knowledge acquisition and its techniques**

Knowledge acquisition is a crucial stage in the development of an expert system. As a process, it involves eliciting, analysing, and interpreting the knowledge that a human expert uses when solving a particular problem.

The RICS/ALVEY research (1988) showed some problems associated with knowledge elicitation. The research pointed out that human knowledge is very complex, it can also be messy and poorly structured. Human beings find it difficult

to articulate what knowledge they have and how they use it to solve problems. While there are no definitive techniques for expert knowledge acquisition which can guarantee complete success, the research (ICs/ALVEY. 1988) categorises some of the commonly used knowledge acquisition techniques as follows:-

( a ) Verbal protocols.

In this technique the expert thinks aloud whilst working, and that allows the knowledge engineer to record and take notice of the expert knowledge in the area. The knowledge engineer then can incorporate this in the knowledge base at a later stage.

( b ) Observational studies

The expert makes retrospective comments on a videotape record of working. This method is useful in giving the knowledge engineer a better chance and more time to view the expert's work. The knowledge engineer can go back to those tapes if more details are needed about a particular point.

( c ) Interruption analysis

The expert is interrupted during the course of working to explain what is occurring. Here the knowledge engineer gets the chance to stop the expert and ask questions about the expert's work. This gives the knowledge engineer the chance to correct any ideas which are thought to be wrong.

( d ) Incremental simulation

This involves focusing on one small aspect of the job at a time. This method tends to break down the knowledge into small sections that can be dealt with separately. These sections will be combined to form the context in the knowledge base.

( e ) Informal interviews

This is where either structured or unstructured formats are used through example cases. The knowledge engineer will meet in regular stages with the expert in informal interviews to discuss different aspects of the knowledge base.

( f ) Mixed methods

A combination of the above methods, where the knowledge engineer and the expert would combine two or more knowledge acquisition methods. The combination would usually be determined by the type of subject and extent of knowledge that is needed.

These techniques differ in their effectiveness depending on the type of knowledge being sought and the type of expert involved. In a well structured expert system like PC PILE (Yeh et al 1991) there are three sources of knowledge:

- ( i ) published material (e.g. text books, technical reports, specification, etc.);
- ( ii ) experts' experience;
- ( iii ) actual project records.

The main problem in dealing with information in the construction industry, as posed by Jean Michel (1983) regards the increasing supplies of crude information - but not "refined" information - leading not only to information overload but also to situations where available information is not suitable for the intended use.

### **5.6.1 Functions in knowledge acquisition and its related problems**

Breuker et al (1987) have identified the major functions in knowledge acquisition to be;



( a ) The elicitation of data on domain knowledge.

At the initial stage of the analysis. written documentation can and should be used. As written sources hardly contain information on how knowledge is being used. other data have to be elicited from experts by interview techniques. and in particular thinking aloud procedures.

( b ) The analysis of verbal data. Analysis is the transformation of data into interpretative framework. Breuker et al (1987) went on to discuss the problems associated with the knowledge acquisition process, notably the problem of selecting and eliciting the data. Most of the data on expertise in action are not in written form, so it is elicited in an incomplete and unstructured verbal form with the possibility that it may be unreliable and contradictory.

### **5.6.2 Knowledge elicitation using personal construct technology**

Personal construct technology proposed by Kelly (1955) is an important knowledge elicitation method. The theory enjoyed considerable success and was handled by different writers in the fields of psychology and computer science.

Aspinall and Newman (1988) explained that according to Kelly, each person builds for himself a representational model of the world, which enables him to plan a course of behaviour. Building-up a set of expectancies (hypotheses) from birth can clearly reflect on past experiences. However, the crucial point is that these hypotheses influence and condition our present and our anticipation of the future. A construct is an aspect, feature or quality which distinguishes some objects from others in which the most useful constructs are those which discriminate best between events.

Aspinall and Newman (1988) have identified the following steps as a way to implement the method in practice:-

( a ) The selection of a set of elements representative of the area wish is to be explored.

( b ) Random sets of elements are taken 3 at a time and a person is invited to think of similarities and differences between them. The standard question is:- "In what way are two of these alike and different from a third in terms of "the purpose of the study"?

( c ) The person ranks or rates all elements on each Construct, noting those elements which do not fit in a particular construct.

( d ) The element by construct matrix is then analysed for its underlying structure (e.g., by cluster analysis, principle component analysis, multi-dimensional scaling).

( e ) Aspects of the matrix, in particular close association between elements and constructs, are fed back to the subject, who is invited to respond with more elements or constructs.

A program system has been developed by Shaw and Gaines (1987) to handle knowledge-engineering problems using personal construct methods. The program is called PLANET (Personal Learning, Analysis, Negotiation. and Elicitation Techniques). It starts with PEGASUS a highly interactive program that elicits construct through a conversational dialogue with an expert, and ending with DATA,

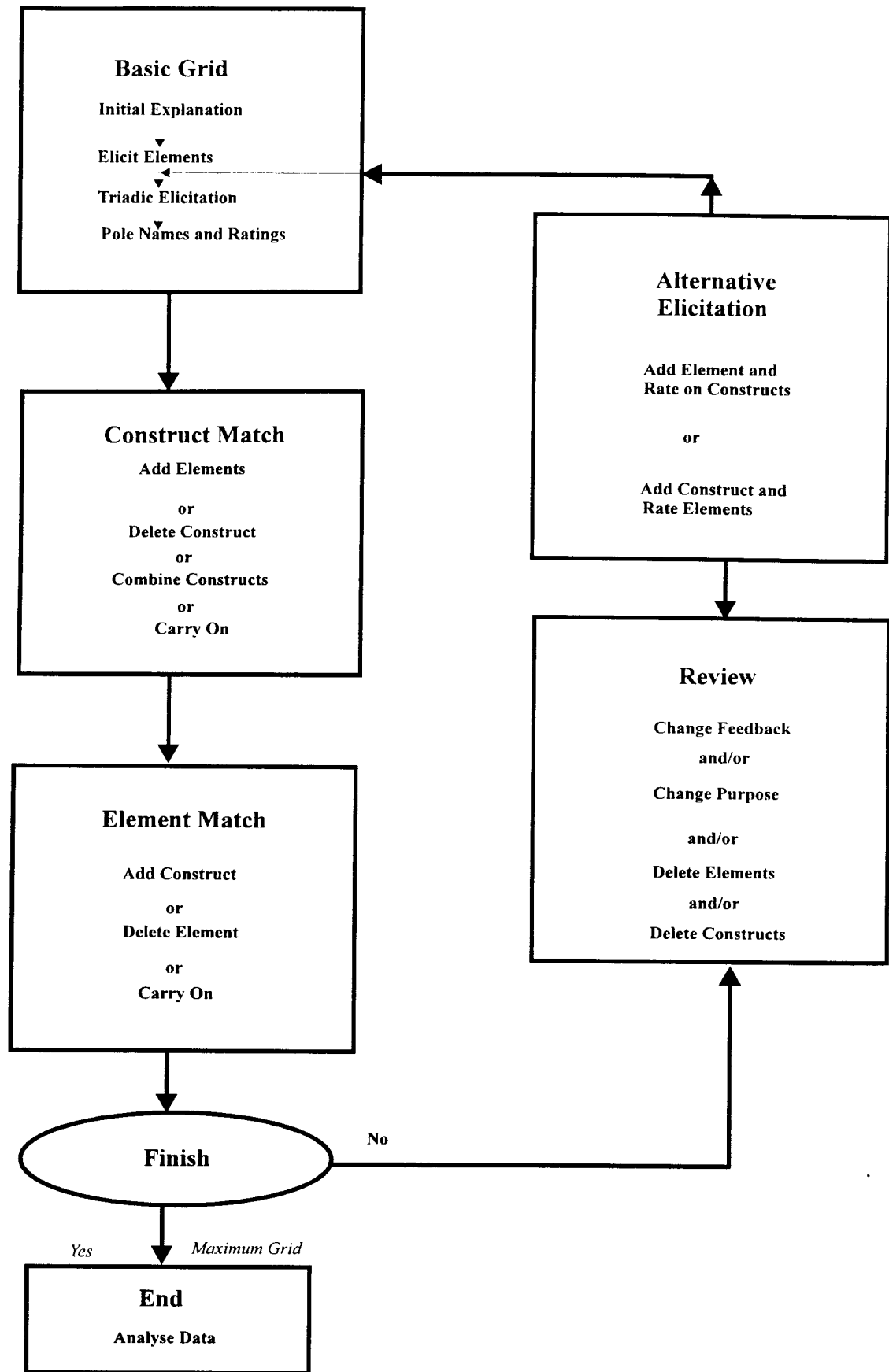


Figure 5.2 Flow of control in PEGASUS

INPUT, OUTPUT and other programs to provide facilities needed for the database administration.

The technique allows PEGASUS to elicit additional elements by matching constructs across elements and asks for a new element that differentiates between two highly matched constructs as shown in Figure 5.2.

But even with the facilities offered by computer-based knowledge-engineering systems, basic problems could exist that could not be solved by this modern facility. Kelly stressed that people are not necessarily articulate about their information. Even the elements which are constructed may have no verbal handles which can be manipulated and the person finds himself responding to them with speechless impulses.

### **5.6.3 The Diagnosis of Knowledge**

The measurement of knowledge has as long a history as the educational system as a whole. Over the years a number of ways of approaching this problem have been tried, involving both the more technical aspects of educational measurement as well as attempts at more thorough re-evaluation (Marton 1997). Experts/trainers are usually expected to know the extent of the learner's previous knowledge. This follows from the fact that every knowledge item has prerequisites. For instance, the concept of a fraction can be traced back to the principle of additive decomposition and to the procedure for counting the elements of a set.

These knowledge items can, in turn, be traced back to their prerequisites, and so on. But if all knowledge builds on previous knowledge, then there is no absolute starting

point for teaching. The selection of a particular topic as the target for training is therefore warranted only if the trainer knows that the student has previous knowledge of the prerequisites of the topic.

It follows that in order to have an accurate estimate of previous knowledge, the trainer must diagnose the knowledge state of the individual learner. This can be achieved through the introduction of some diagnostic task in the form of general concepts and questions which could be performed by learners (Goodyear 1990).

#### **5.6.4 Artificial Intelligence and knowledge**

O'Shea and Self (1984) explains that Artificial Intelligence attempts to study knowledge aspects and ways of presenting it through the development of knowledge based systems and through other knowledge representations methods. It has been found that the computational analogue of thinking depends not on general-purpose procedures, like the laws of logic, but rather more on the skilful use of specialised knowledge retrieved from experts memory. For this retrieval to be passably efficient, the knowledge has to be well-organised or highly structured.

Goodyear (1991) pointed out that specialists knowledge is rather heuristic by nature and is seldom found in written forms; moreover, this knowledge usually appears to be difficult to elicit by means of using only published materials. A much used technique to get at this type of knowledge is asking experts in a detailed and structure manner on a particular subject and to capture the knowledge of that subject through a series of discussions and interviews. The main problem involving information in the construction industry, as posed by Jean Michel (1983) regards the increasing supplies of crude information - but not "refined" information - leading not only to

information overload but also to situations where available information is not suitable for the intended use.

### **5.6.5 Technique of knowledge acquisition applied in the research**

Kidd (1987) has suggested that knowledge acquisition is a crucial stage in the development of an expert system. As a process, it involves eliciting, analysing, and interpreting the knowledge that a human expert uses when solving a particular problem and then transforming this knowledge into a suitable machine representation. In developing an expert system it is important that accurate consideration is given to the final users of the system, and to realise at an early stage who the end user will be and take their needs into account.

In our research for developing the construction management expert system for training, we used the "production system model" in which the knowledge is considered as a set of rules. The knowledge required for this was acquired by a variety of ways as described below.

#### **5.6.5.1 Documents**

The specific sources were training manuals on contract management and safety management prepared specifically for project management training courses by ADEPT, a training management consultancy.

These manuals are produced from;

( i ) Contract Management lectures from experts (detailed information on the following headings can be seen on the contract management expert system in Appendix A. The manuals addressed the following :

- a. Introduction to contract management.
- b. Project objective.
- c. Planning and management of a project.
- d. Contract strategy.
- e. Contract selection.
- f. Function of an engineering contract .
- g. Contract administration and terminology.
- h. The law of contract.
- i. Documents for engineering contract.

( iii ) Safety Management lectures from experts (detailed information on the following headings can be seen in the safety management expert system in Appendix D). The manuals addressed the following :

- a. Safety management introduction.
- b. Safety management definitions and beliefs.
- c. Forms of accident.
- d. Safety planning.
- e. Company safety policy.
- f. Control of contractors.
- g. Safety and law.

#### **5.6.5.2 Video**

While there are no definitive techniques for expert knowledge acquisition which can guarantee complete success, the RICS/ALVEY research (1988) pointed out that video tape (known also as observational studies) recording can assist the task of the knowledge engineer in achieving a deeper understanding of the knowledge that is being considered for the build up of knowledge base.

Two video seminars on contract and safety management were recorded as part of the ‘teach back method’ which was discussed in chapter 4. This technique is known as observational studies (see chapter 4 methods of knowledge acquisition) where the expert makes retrospective comments on a videotape record of working.

In the case of this research the video recording of two training sessions which was conducted by the experts on the fields of contract and safety management was recorded by the author to help enhance the author’s general understanding of the subjects. The video tapes were not included as the main source, but the knowledge base came from the interviews and the published material that was designed by the experts to include their experience in the field of contract and safety management..

#### **5.6.5.3 Interviews**

Hayes (1983) suggested that knowledge acquisition based on structured interviews usually involves several meetings between the expert and the knowledge engineer. This is due to a process of knowledge refinement. The knowledge engineer will complete an interview and inwardly digest the new information which was obtained from the expert.



Hayes (1983) suggested further that all interviews should be tape-recorded because information which seems unimportant during some interviews, may become later very useful, and if this information is not captured then it may get lost. This technique was used in all of the interviews carried out for this research.

Experts in the field of project management were interviewed to acquire their knowledge about the problem in-hand. The interviews were carried out with 4 experts, two of whom were professionals who worked in the field of construction project management through the full spectrum of construction projects and were also experienced in the field of management training. This was also important in the overall objectives of the expert system which was being used as an aid to training in construction management.

The other two experts were academics. One of them has completed research studies related to construction management training and the other academic, a Psychologist, has researched in the area of human/computer interaction which is an important element in the evaluation of the expert system which is presented in chapter 7.

The interviews included a teaching back method (Johnson and Johnson 1987) in which the experts give a description of a procedure or some piece of content. The interviewer teaches it back to the expert using the expert's terminology, seeking conjunction of whether or not they were doing it the same way. If the expert disagrees, the investigator asks the expert for further information or instruction. The cycle of teach and teach back is repeated until the expert is satisfied that the investigator is doing the same thing. The usefulness of the structured interviews allowed the interviewer to step into new ground that the expert might find important or might find himself acquainted with, with no difficulty.

The development of a particular expert system required a knowledge of the subjects of contract management and safety management on the one hand and skills on the design of evaluation question tests on the other. Questions that were presented in the evaluation tests were provided as part of the expert system in order to allow each trainee to monitor their performance, and the ability to understand the information presented to him on the subject.

The use of terminology in contract and safety management areas was shaped to suit the expert's presentation, allowing him to express his knowledge in his own words and terms. Information extracted from one interview was used in the following one, allowing the next expert to give his own ideas about them, generating and simulating information to rise to the surface.

The interviews were analysed and the knowledge gained on both contract and safety management were compared to the training manuals. Knowledge and information provided in both sources were utilised to form the knowledge base for the expert system.

#### **5.6.5.4 Mixed methods**

In this technique the knowledge engineer and the expert would combine two or three knowledge acquisition methods. The combination would usually be determined by the type of subject and extent of knowledge that is needed. These techniques differ in their effectiveness depending on the type of knowledge being sought and the type of expert involved. In a well structured expert system like PC PILE (Yeh et al 1991) there were three sources of knowledge:

- ( i ) published material (e.g. text books, technical reports, specification, etc.);
- ( ii ) experts' experience;
- ( iii ) actual project records.

## **5.7 Evaluation of expert system**

Evaluation is concerned with gathering information and data regarding the usability of the expert system, and this was carried out by a specified group of users (trainees) within a specified work context (Preece 1994). Evaluation also provides ways of answering questions about how well a design meets users needs of understanding the subject matter. Different evaluation feedback was carried out at different stages of the expert system design process.

When the expert system was initially being built evaluations were carried out by the experts themselves (this is known as formative evaluation, Preece 1994), and all changes suggested were implemented.

On completion of the expert system, summative evaluation had to be carried out in assessing the finished product and was based on the following variables, classified under sections 1 to 6, (Table 5.1) as they emerged from the literature on the evaluation of knowledge based systems and the subject matter (contract and safety management).

- ( i ) *Section I* Human computer interaction.

When considering human-computer interaction in knowledge based systems Polson (1988) emphasised making appropriate trade-offs between the design of the knowledge base and the systems interfaces. Polson explains further that the learner

working with IT generally has two problems. First, the learner must learn some subject matter that he or she may not understand, while, the other problem, using technology that is unfamiliar. If the human computer interaction is poorly designed, a training session will probably be ineffective. If the learner has to spend significant intellectual energy working the computer, then the learner has less intellectual and emotional energy for learning what is supposedly being taught.

Questions in human computer interaction related to;

- titles and screen formats
- information presentation
- keyboard instruction
- display form's key points
- speed of navigation through the expert system and expert system efficiency

( ii ) *Section 2* Attitudes towards computing.

Research carried out by Scott et al (1994) into attitudes towards computing in the construction industry had revealed that computing skills are now considered as a basic literacy skill by the construction industry, but there still was a need to improve those skills. Hence it was decided to include this concept within the questionnaire in order to find out the level of appreciation in the usage of computing among trainees. in the industry.

Questions on attitudes towards computing related to;

- time and work saved with such systems
- processing of information
- need for a comprehensive expert system
- new technologies and its effect, i.e. computers as an educational tool
- computers and routine tasks

( iii ) *Section 3* Knowledge base design.

This section considers aspects of knowledge presentation such as the structure of the display forms and presentation of the contents the knowledge base. The section also examined whether learners had any difficulties with the selection and sequencing of the subject matter. Polson (1988) explained that clarity of information flow in the knowledge base helps to clarify the facts and subject concepts, which means that learners can achieve a deeper understanding of the subject.

Questions on knowledge base design related to;

- ability to cover the subject in hand.
- ability of display forms to give a clear understanding of the subject
- reading required prior to using the system
- standard of expert system
- number of display forms needed to cover the subject

( iv ) *Section 4.* Expert system for training.

This section deals with trainees perception in using such a technology in training. The main aim of this section was to find out if trainees have found such a system beneficial in enhancing their knowledge on the subjects of contract and safety management.

Questions on the use of expert system for training related to;

- expert system ability to improve work effectiveness
- trainee performance in using an expert system or a lecture
- complications of using an expert system
- expert system as a supporting tool during training courses
- usage of expert systems in project management
- expert system benefits in education and industrial settings

- expert system ability to improve knowledge on contract and safety management
- expert systems could result on time saving
- performing the evaluation training programme improves knowledge
- time given to perform the training programme
- trainees evaluation after a training programme is vital
- learning from expert's experience

( v ) *Section 5.* Expert system evaluation tests.

This section deals mainly with the evaluation tests which was built-in the knowledge base. Evaluation tests was designed to allow trainees to assess their learning progress and to give them an effective feedback of their performance at any point of the training program.. Bentley (1992) has identified that feedback is important to reinforce learning, to assess learning progress, and to encourage learning. Bentley further points out that in computer-based training programs, particularly those concerned with learning new systems, it is important to provide the opportunity for learners to practice what they have learned by providing a comprehensive set of evaluation exercise.

Questions on the evaluation tests related to;

- structure
- ease of understanding the questions within the evaluation tests
- ability to provide information on trainee performance
- importance of defining standards of trainees at early stages

( vi ) *Section 6.* Knowledge of Contract/Safety management

This section is aimed at analysing and characterising the levels of knowledge and kinds of abstraction which learners might have faced during the training program. The section also seeks to examine trainee's pervious knowledge on contract and

safety management, and whether the knowledge presented to them in the expert system has contained most aspects of contract and safety management or whether more knowledge upgrading is still required.

Questions on this section related to;

- knowledge required to cover the four different levels in the expert system
- knowledge required on contract and safety management before starting the expert system
- need for written information prior to using the system
- past experience on subjects of contract and safety management

Table 5.1 summarises the variable and lists the corresponding questions in the evaluation questionnaire.

<b>Title</b>	<b>Section</b>	<b>Questions</b>
Attitudes towards computing	1	Q26, Q27, Q28, Q34, Q35, Q40.
Human computer interaction	2	Q1, Q2, Q3, Q21, Q22, Q23.
Knowledge base design	3	Q4, Q6, Q19, Q37, Q25.
Expert system for training	4	Q5, Q8, Q9, Q10, Q12, Q13, Q14, Q16, Q18, Q20, Q23, Q24, Q29, Q39.
Expert system evaluation tests	5	Q7, Q15, Q31, Q32.
Trainees knowledge of contract management	6	Q11, Q17, Q30, Q36, Q38.

Table 5.1 Questionnaire sections

The purpose of the evaluation questionnaire was to get feed back on the expert system from trainees. Two evaluations were carried out on the two expert systems tools, (Safety Management, Contract Management). The contract management expert system was used in a group due to machine and course limitations, but 26 individual questionnaires were completed. The safety management expert system tool was used and evaluated by 30 individual trainees. The evaluation was carried out as part of a project management course run by a recognised training company.

The evaluation was performed in three stages. In the first instance trainees were asked to read a hand out which provided them with the background to the expert system and gave full instructions on the use of the expert system. In the second stage they proceeded through the contract management expert system and were asked to take notes of scores achieved during the evaluation test, which were recorded on a separate form. In the final and third stage trainees were asked to complete an evaluation questionnaire. They were asked to give their views on the expert system tool and also to give feed-back on the whole experiment.

## **5.8 Methods used to analyse individual response**

### *Likert scales*

Likert scales (Tull 1990) were used to compare the responses of the trainees. These scales, (also known as summated scales) ask the trainee to indicate a degree of agreement or disagreement on a particular topic. The analysis is based on assigning numerical values to the trainee's response.

An example of the numerical values assigned are: strongly agree=1, slightly agree=2, no opinion=3, slightly disagree=4, and strongly disagree=5 . Likert scales are usually



analysed on an item to item basis or a single score can be presented to each subject. Details of the analysis are provided in chapter 7.

### *Factor analysis*

Factor analysis was carried out, using the Statview 4.5 by Abacus concepts computer package run on an Apple Macintosh, to help explore the relationship between variable based on the trainees responses to the questionnaire. Glynis (1995) described factor analysis as a global term which is used to describe a wide variety of different techniques to examine the existence of latent traits. As with most methods for examining structure, factor analysis begins with the calculation of the intervariable correlation matrix.

The analysis proceeds to identify the set of underlying linear traits that are best implied by the intervariable relationships. The factor analysis treats the correlation matrix as a ball of intervariable variance and it extracts chunks of variance to represent each underlying factor sequentially. These chunks get smaller as each factor is extracted (factor analysis of trainees responses can be seen in chapter 7).

## **5.9 Summary**

In this chapter the research methodology and the knowledge acquisition stage was discussed. Knowledge acquisition is the bottle neck of building any expert system. The knowledge acquired has be reliable and the analysis of this knowledge structured deep enough to provide the basis for writing the rules of the expert system. Another important factor was the expert system evaluation method applied in this research. Evaluation results will be discussed in depth in the expert system analysis and discussion chapter (chapter 7).

The following chapter (chapter 6) will discuss the stages in which the expert system was built, including the way in which the rules were structured.

## **Chapter 6 Building the Knowledge-Base Expert System**

### **6.1 Introduction**

The next step in the development of the expert system for training and after the knowledge acquisition stage has been completed, is to structure the rules for the system using the development tool. In our research the rules had to be written to provide the trainee with consultation on two subjects, Contract and Safety Management. The expert system was designed with built-in evaluation tests. The evaluation tests in the expert system were constructed to contain four sections, general, basic, intermediate, and advanced section. It was written to suit trainees with little information about the subjects and with modest training requirements. Also to allow trainees with more knowledge about the subjects to increase their knowledge by getting the expert system to meet more advanced training requirements.

### **6.2 Choice of a development tool**

Although languages and environments offer great flexibility in building expert systems. Yet their relative difficulty in dealing with such vast amount of knowledge compared with the shells and their built-in facilities (as was discussed earlier in chapter 4) shifted our thinking from using a language or an environment to building the system using a shell.

Again we were faced with the problem of choosing between different shells of different types. The possibility of choosing an induction tool like "SUPEREXPERT" was eliminated due to its inadequacy to handle slightly complex problems. The other available shells were "LEONARDO Level 3", an object oriented tool, and

"CRYSTAL Version 4.5", a structural rule-based tool. After working with the two shells, getting acquainted with their capabilities through different applications developed using them, assessing their performance against the criteria mentioned in Chapter 3, it was decided to choose "CRYSTAL Level 4.5".

### **6.3 Choice of Construction Management Aspects**

Several areas of management can be included under the definition of construction management. Having examined the literature on existing expert systems for use in construction management, the following two subjects were poorly served. They were thus adopted for this research.

#### **( i ) Contract Management :**

The process of developing contracting approaches and administering contracts through the life of projects involves several kinds of expert decision making. Representative decisions in this area involve: selecting an overall contracting approach or strategy; selecting contract clauses to incorporate; identifying and refining project financing or insurance options; qualifying or selecting prospective contractors or designers; evaluating progress payments; evaluating potential claims or litigation situations; quality assurance; and project organisation design.

#### **( ii ) Safety Management :**

Safety management is the managed control of accidental loss. In project environment, safety must be managed; and thus it should have equal managerial status with the project's macro objectives of schedule, budget and quality. Safety working practices are vital to the overall efficiency and success of projects large and

small. In order to minimise loss in construction projects management attention must be focused on safety management.

#### **6.4 Design of the ( Contract & Safety Management) expert system structure**

The expert systems for contract and safety management are rule-based. They were designed to provide a reasonable level of knowledge on various aspects of contract and safety management. The sequence through which the expert system runs is shown in Figure 6.1. The expert system begins with a short introduction to direct the user through the package and the different evaluation stages on completion of each training section. Trainees then will choose from the menu the subject which they wish to improve their knowledge on. After choosing the subject the trainee then starts from section 1 which is the general section. In this section trainees are requested to read through an introduction section to the subject.

The general section will consist of general knowledge on contract or safety management followed by an evaluation test. The general evaluation is designed to allow the expert system to decide on the section which is most suitable for the trainee to start from. Depending on the general evaluation result the expert system directs the trainee to go to either the basic or the intermediate section. If the trainee performance is not satisfactory then he is asked to start at the basic section where he will be presented with a number of display forms displaying the knowledge on the subject at that section.

Once the trainee has satisfied all the conditions he may proceed to the next section on the system which is the intermediate section. At the intermediate section the knowledge presented to trainees gives more depth to the subject and trainees are

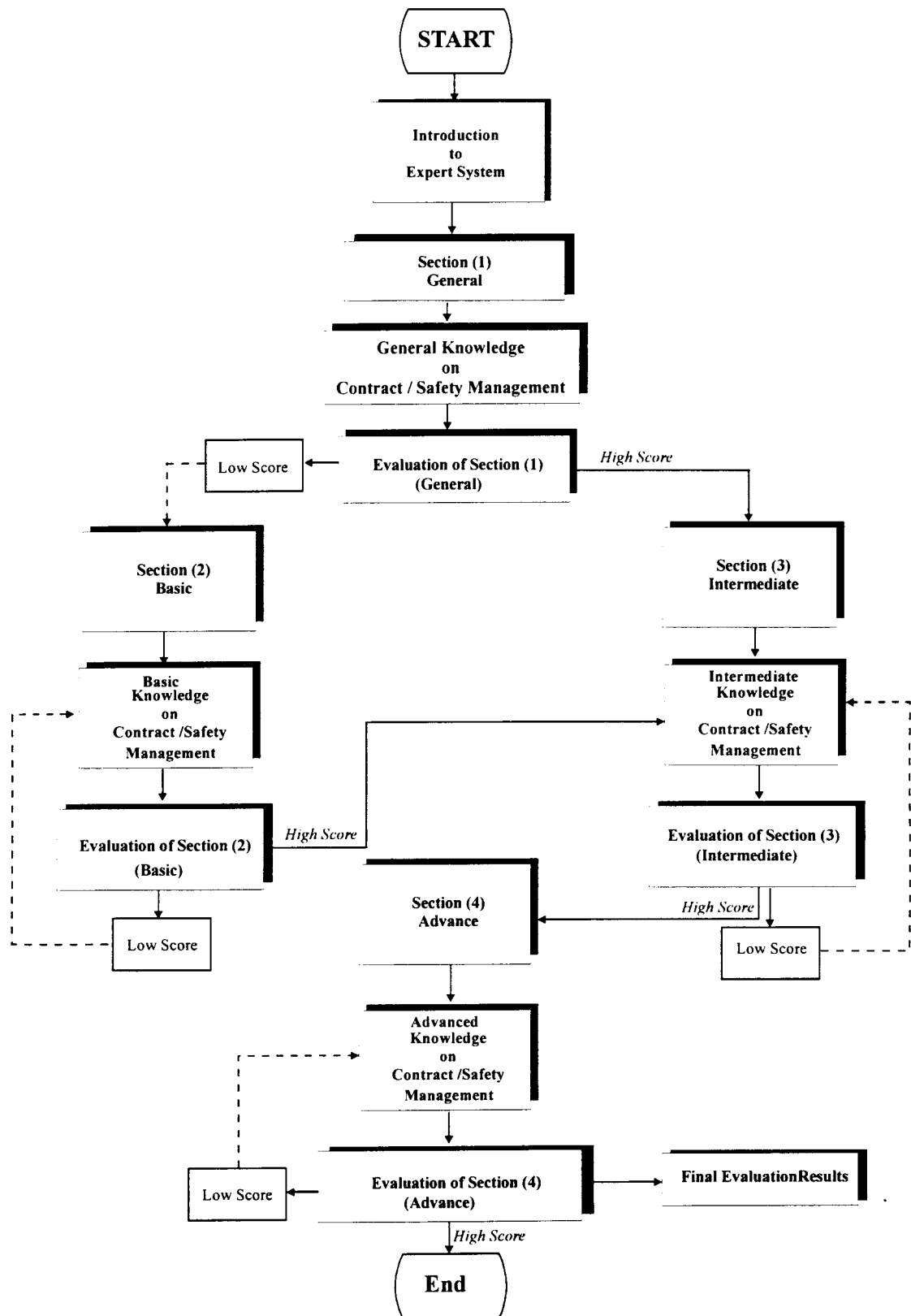


Figure 6.1 Expert System flow chart

requested to go through another evaluation test in order to assess the trainee's performance before being allowed to proceed further in the expert system to the final section which is the advanced section. Information displayed in this section is of a high standard in the subject chosen. On completion of the final stage of the expert system all trainees are expected to have improved their standard and knowledge on contract and safety management.

At the end of the expert system the trainees are given the choice to start the expert system again ( their scores should indicate to them their final performance) if they feel that they have in-sufficient knowledge of the subjects.

## **6.5 Knowledge-base structure**

All expert systems have knowledge bases containing the knowledge for the particular domain to which they are dedicated. Within this knowledge base, there will be knowledge about the actual domain as well as problem-solving knowledge for running the consultation. Both types of knowledge in this research were represented by using the representation formalism of the production rules. The production rule operation was discussed in chapter 4.

An integral part of the expert system is its knowledge or rule base. This is where the domain knowledge of the system exists in the form of facts and rules. CRYSTAL 4.5 is a well-structured expert system shell, and therefore forces a structure on the rule-base. However, this does not prevent the expert system builder ordering the rules in order to impose a sequence on the questions which are asked. In this research, about 800 rules were implemented in each subject and they were grouped into four main sections. A number of rules developed were in the form of menus and

contained information on the evaluation tests. Display forms were used to display knowledge on contract and safety management at four different sections; general, basic: intermediate and advance section.

The grouping of rules were designed to force all questions relating to a particular section of knowledge to be asked together, which is a sensible method of ordering questions. It would have been more difficult for trainees to follow questions from different sections of the expert system at the same time. Human experts also tend to deal with one topic at a time.

The rule base was incrementally developed from the knowledge acquired at the interview sessions and from the training manuals on contract and safety management. The majority of the rules were in place after the early interviews with the experts. The later interviews were used to improve the reliability and accuracy of the rules and the information presented within the knowledge base. The following is an example of the structure of a rule:

IF : basic knowledge processed  
AND : evaluation processed  
AND : score > **80%**  
THEN : proceed to intermediate section.

The nature of the domain meant that it was possible to have different types of rules. One type accounted for factors which dealt with processing the knowledge display forms. A second type accounted for factors which dealt with processing the question menus in the evaluation stage and assigning their scores and the final type of rule supported the first two, making the necessary calculations and conclusions.



The activated rules will allocate different values to four sections of evaluations as follows :

- ( i ) The first group of values is responsible for the general section evaluation.
- ( ii ) The second group of values is responsible for the basic section evaluation.
- ( iii ) The third group of values is responsible for the intermediate section evaluation.
- ( iv ) The third group of values is responsible for the advanced section evaluation.

The values were reset to null value at each commencement of the expert system as shown below :

```
IF : Assign General : = 0
AND : Assign Basic : = 0
AND : Assign Intermediate : = 0
AND : Assign Advance : = 0
AND : Display Form
OR : Test Rerun = 1
```

By identifying all sections through a set of rules, each section will have a specified location in the knowledge base. For example if the user completed the general section, and managed to obtain a high score, the system would direct the user to go to the intermediate section and at this point the rules that deal with the intermediate section would be activated. In activating the intermediate rules, the system will start

informing the user that he is about to start the intermediate section and all the rules present in this section would be activated one after the other.

The structure of the rules are important because :

( a ) Rules should be easy to read for the system user. Since rules form the basis of the justification given by the system for the conclusions it reaches, they should be clear and concise to both the system developer and the system user.

( b ) Easy to read rules are essential for maintenance purposes. System maintenance is an issue which tends to be neglected in a great deal of expert system literature. Expert system domains are often subject to constant change. Once developed an expert system will require constant modification to keep up with any new changes and development within the domain. The maintenance process should not have to rely on the system developer but should be undertaken by the user or a Computer Services department.

## **6.6 Design of Expert System Evaluation Tests**

The evaluation tests were designed to allow the user to be able to assess their performance during a training session and to give an indication on the improvement gained on the subject. Much of the data is collected from the trainees when the knowledge based system is running, and is in response to the menu question screens. The data that the user will input (the answers to the questions asked by the program) will activate the rules in the rule-base, which were all edited by the programmer according to the knowledge acquired from the experts in the interviews. The evaluation tests in the expert system were structured in the form of statements on

particular points on the subject (contract and safety management) followed by different choices of answers. The trainee is expected to understand the statements and try to match it to the correct answer. The trainee's performance will depend to a great deal on understanding of the section evaluated.

### **6.7 Design of evaluation questionnaire**

The expert system evaluation questionnaire was carried out in order to get a feed back from the users on both expert systems. The evaluation questionnaire was carried out at the end of the training program for contract and safety management. The questions were used to evaluate the trainee's understanding of each section of the expert system and his appreciation of such systems to be used in management training. The results of each individual response were recorded and analysed in chapter 7. The wording and understanding of the questions were also analysed as part of the total evaluation of the training program, and this can also be seen in the following chapter. The questions on the topics were put together by both the author and the expert. Questions can be seen in appendices B and E.

### **6.8 Summary**

This chapter has been devoted to a discussion of the design of contract and safety expert system structure. In the process many important issues have been raised such as the consideration that was giving in the selection of the development tool, and the structure of the rule-base which had been implemented during the development of the expert system, and finally the evaluation test technique that was employed in the expert system as an important function of training. In the next chapter (chapter 7), a

comprehensive evaluation of the developed expert system was carried out and results of the evaluation are analysed in depth.

## Chapter 7 Analysis and Discussion

### 7.1 Introduction

This chapter presents the analysis of the expert system evaluation questionnaire, (safety and contract management expert systems) results of trainees evaluation tests which was carried out during the expert system training program and finally the results of the factor analysis method which was used to justify the variables in table 7.1. The evaluation questionnaire contained 40 questions based on six major sections of the expert system evaluation, shown in table 7.1. Also included are the numbers of the questions which provided responses to these sections.

Title	Section	Questions
Attitudes towards computing	1	Q26, Q27, Q28, Q34, Q35, Q40.
Human computer interaction	2	Q1, Q2, Q3, Q21, Q22, Q23.
Knowledge base design	3	Q4, Q6, Q19, Q37, Q25.
Expert system for training	4	Q5, Q8, Q9, Q10, Q12, Q13, Q14, Q16, Q18, Q20, Q23, Q24, Q29, Q39.
Expert system evaluation tests	5	Q7, Q15, Q31, Q32.
Trainees knowledge of contract management	6	Q11, Q17, Q30, Q36, Q38.

Table 7.1 Questionnaire sections

The questionnaires are given in appendix B and E. Tables 7.2 and 7.7 summarise the responses to the questionnaire.

## **7.2. Contract Management Expert System Tool**

This section deals with the analysis of the trainee's responses in both the expert system performance scores and the feed-back questionnaire. Discussion in the following sections have been obtained from responses to individual questions, but due to the large amount of graphs that were produced in this section only the total responses to each section will be shown.

Detailed trainees response's to each question can be seen in appendix C with averages for the individual questions.

### **7.2.1 Attitudes towards computing**

There are six questions in this section which deal with the general attitudes towards computing. Q26 examines whether time and work could be saved with the use of computers in training. A large number of trainees, 31%, responded to this question by choosing not to commit themselves at this stage, i.e. by choosing to answer to having no opinion. Although there was some agreement and disagreement, with a mean of 2.9, the main response was one of uncertainty, as expected from undergraduates with little work experience. Another question in this section, Q27, suggests that expert systems are superior to humans in processing information. While a majority of 46% agreed, a substantial number, 27%, disagreed. This uncertainty again may be due to a lack of understanding of what an expert system does. Q28 dealt with whether more effort is needed to build further comprehensive

expert systems, and trainees responded with about 60% agreement. This suggested that there is a need from both computer science and project management researchers to build more comprehensive expert systems.

Q34 asked trainees whether the expansion of new technologies is making working conditions better. Over 60% agreed with the above, but 35% of trainees may have through a lack of work experience, expressed no opinion. The last two questions (Q35, Q40) tackled a similar idea, and that is to find out whether trainees feel that computers are needed in education and whether they are looking forward to computers taking over more tasks in both education and work environments. These points gained agreement of 77% and 62% respectively. Trainees agreed that computers are becoming more important in education and work. Trainee's general response towards computing is presented in figure 7.1, where an agreement of over 53% shows that trainees are interested in allowing computers to take over more jobs in their work.

Question	Mean	Agreement	Disagreement	No opinion
Q1	2.1	61.5%	11.5%	26.9%
Q2	2.7	34.6%	7.7%	57.7%
Q3	1.5	84.6%	0.0%	15.4%
Q4	2.1	73.1%	7.7%	19.2%
Q5	2.7	46.2%	23.1%	30.8%
Q6	2.7	38.5%	23.1%	38.5%
Q7	2.7	38.5%	19.2%	42.3%
Q8	1.7	80.8%	7.7%	11.5%
Q9	2.8	30.8%	19.2%	50.0%
Q10	2.0	76.9%	3.8%	23.1%
Q11	3.1	26.9%	38.5%	34.6%
Q12	2.7	42.3%	15.4%	42.3%
Q13	2.4	50.0%	7.7%	42.3%
Q14	2.9	30.8%	26.9%	42.3%
Q15	2.7	53.8%	23.1%	23.1%
Q16	3.0	23.1%	30.8%	50.0%
Q17	3.2	34.6%	50.0%	15.4%
Q18	2.8	38.5%	23.1%	38.5%
Q19	1.7	88.5%	3.8%	7.7%
Q20	2.7	38.5%	19.2%	42.3%
Q21	2.6	42.3%	15.4%	42.3%
Q22	2.5	50.0%	11.5%	38.5%
Q23	2.6	38.5%	7.7%	53.8%
Q24	3.0	23.1%	23.1%	57.7%
Q25	3.4	15.4%	46.2%	38.5%
Q26	2.9	38.5%	30.8%	30.8%
Q27	2.7	46.2%	26.9%	26.9%
Q28	2.3	61.5%	7.7%	30.8%
Q29	2.1	69.2%	7.7%	23.1%
Q30	1.8	84.6%	3.8%	11.5%
Q31	2.5	46.2%	15.4%	38.5%
Q32	2.0	80.8%	3.8%	15.4%
Q33	2.8	46.2%	30.8%	23.1%
Q34	2.3	61.5%	3.8%	34.6%
Q35	2.1	76.9%	11.5%	11.5%
Q36	3.7	23.1%	65.4%	11.5%
Q37	2.1	65.4%	7.7%	26.9%
Q38	2.7	38.5%	15.4%	46.2%
Q39	1.4	92.3%	3.8%	3.8%
Q40	2.3	61.5%	19.2%	19.2%

Table 7.2 Summary of contract management analysis



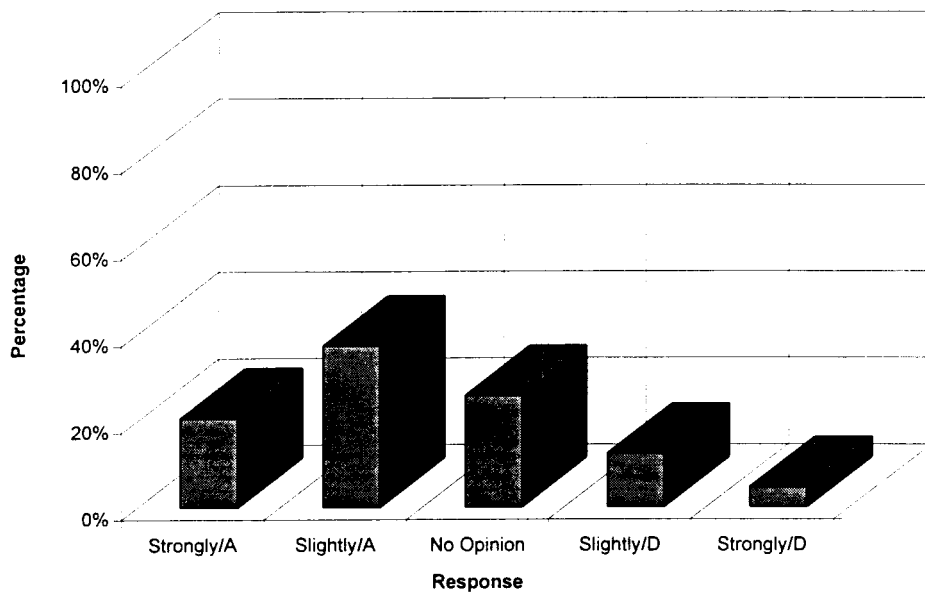


Figure 7.1 Trainees responses to general attitudes towards computing

### 7.2.2 Human computer interaction

Bentley (1992) has pointed out that screen-based instructions such as screen formats and keyboard instructions is considered to be an important elements of good screen design. Hence the questions contained in this section were intended to obtain feed back from trainees on any presentation problems that might be present in the expert system tool, and that will hinder knowledge transfer. The section consisted of six questions. Q1 dealt with the ease of following all titles and screen formats, and the general view, 62% agreement, was that titles and screen formats were not obstacles. On Q2, the trainees were asked to give their response on how adequate was the information presented within the knowledge base. The main features of their response is that 57% chose not to answer either way. This might be due to the fact that they are new to the subject and are not aware of the extent of the knowledge.

When the trainees were asked about how clear the keyboard instructions were, Q3, over 85% said that the keyboard instructions were easy to follow. Question 21, was to find out if the knowledge display forms were easy to follow. About 42% of the

trainees showed that they found it easy to follow while **42%** were not sure and around 15% had difficulties.

From these percentages it was noted that although only 15% of trainees disagreed with the way in which the information was presented to them in the display forms. so that more should be done to improve the lay-out.

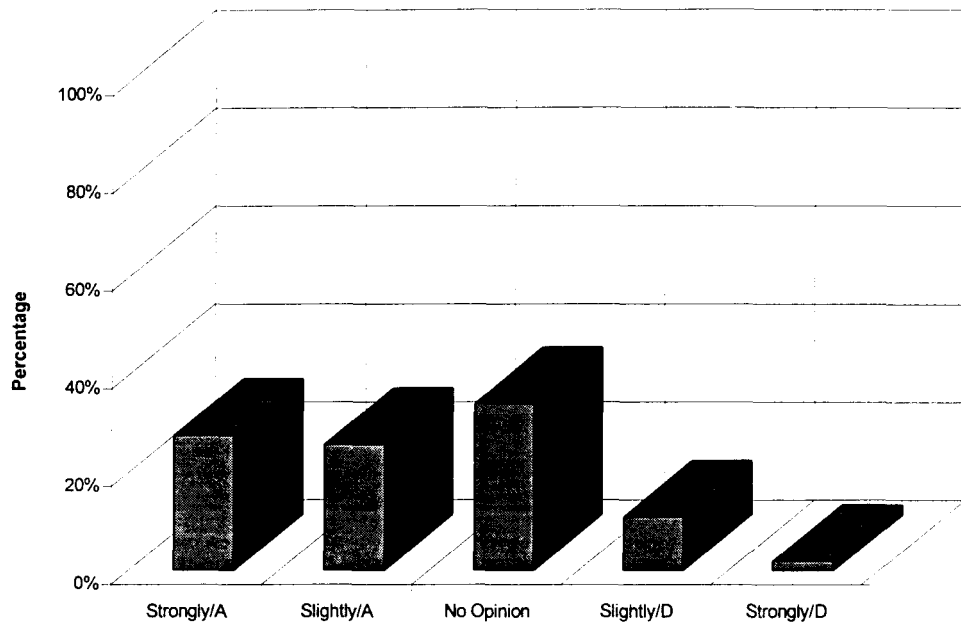


Figure 7.2 Trainees responses to the human computer interaction

Speed of navigation through the expert system was discussed in question 22, and about 50% said that it was adequate and 11% disagreed. This is considered to be a good response since there were over 50 display forms of information to read and understand before going through the evaluation tests. The final question in this section, **Q23**, deals with efficiency of such an expert system. **39%** of the trainees agreed that higher training efficiency can be achieved with expert systems, while **54%** expressed no opinion. This is considered to be a positive response since the concept is new. Only **8%** did not like the idea.

An overall picture on the results of the human computer interaction section is shown in figure 7.2. The results show that over 48% of trainees are satisfied with most of the human computer interaction aspects. It is also noticeable that about 35% of trainees are not yet sure about these aspects and the remaining 10% said that they have faced problems with all the factors that were discussed previously. Despite the variations, overall results agree with the existing interfaces, although some improvements could be made. The percentages also show that many of trainees have managed to obtain a grasp of the information within the allocated time (timing of training program was 40 (Appendix B-1 ) minutes on each subject).

### **7.2.3 Knowledge base design**

This section deals specifically with the actual material that is contained in the knowledge base and it examines all the different aspects which affect the understanding of the subject (Contract Management) and all the trainee's performances with the expert system tool. There are five questions in this section which will be examined individually.

Question 4 was presented to the trainees to get their view as to whether the information on contract management in all four levels of the knowledge base has covered most of the subject. A response of 73% agreed that the contract management information within the knowledge base had actually covered most parts of the subject. This is considered to be a positive response and it shows that although they might have faced some difficulty with the evaluation tests they were able to go back and spend more time in reading the display forms. The other conclusion that we can draw here is that the knowledge gained from the experts on contract management covered most aspects of the subject. 8% of trainees disagreed with the

fact that the contract management knowledge was sufficient to cover all parts of the subject. Within the time allocated for the expert system exercise, it was not possible to provide more information but this expansion can be applied to an updated version

In question 6 about 39% of trainees agreed that the knowledge display forms gave a clear understanding of the subject and this can be related to question 21 in the human computer section where 50% agreed that key points on display forms were easy to follow. A substantial number of trainees have had some difficulties in certain parts of the display forms, and this could be due to the time limit and the vast amount of knowledge contained within the display forms. When trainees were asked in question 19 if they would prefer to do some reading prior to using the expert system and whether it could help them gain a deeper understanding to the questions of the evaluation tests within the expert system tool, they gave a clear, 89%. agreement response. Contrast this to **Q25**, where they were asked if more display forms should be included on contract management, and only 15% agreed. The majority of trainees rejected the idea of more information on screen while desiring further information. This is considered to be a clear indication that expert systems should be one element, and not alone in a training programme.

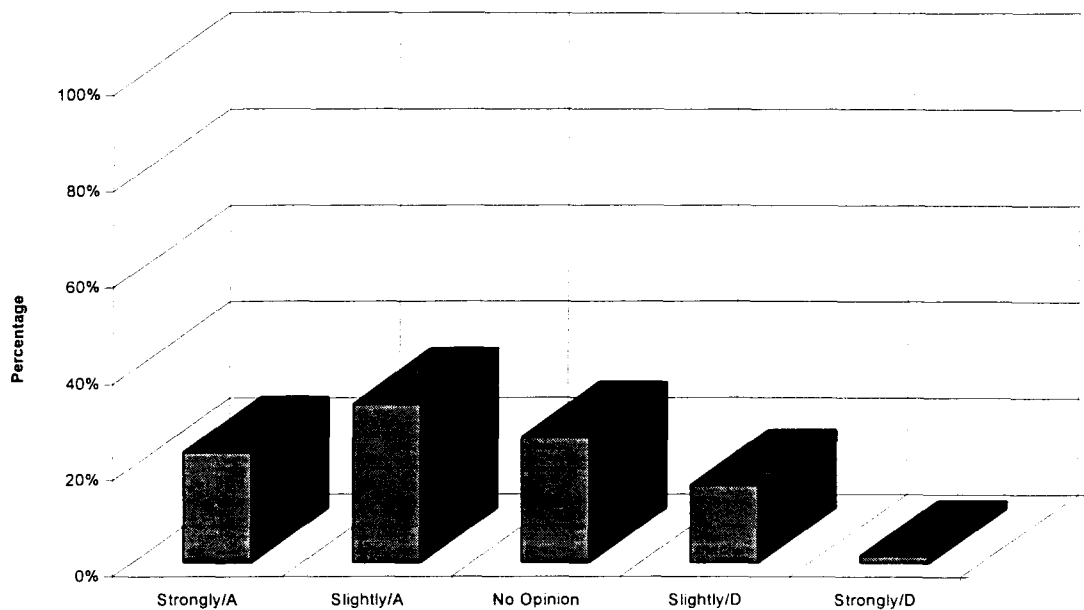
In the final question, Q37, trainees were asked if they thought that the knowledge presented to them in the expert system was difficult to understand. Only 7% thought that was true and around 65% of trainees thought that system was not difficult to understand. The problem with the 7% could lie with the amount of knowledge that needed to be absorbed in the limited time. In this particular research it was difficult, due to technical reasons, to allocate more time to trainees , but if the expert system was to be used in a full training program and as an aid tool to that program, this obstacle can be overcome.

for a higher training level.

Figure 7.3 provides the overall picture of the trainee's responses. It shows that there was hardly any strong disagreement on aspects of knowledge base design 10% slight disagreement and over 50% agreement. Although this is considered to be a good result to a certain extent, it could still be improved by the implementation of the previously discussed issues in this section.

#### **7.2.4 Expert system for training**

This section is considered to be the most important section of the evaluation , due to the fact that most of the questions asked will examine the quality of training that will be produced with the aid of expert systems. The first question here is question 5, where trainees were asked to give their response to whether such systems can improve their work efficiency. 46% of them agreed that it would while 23% disagreed. It was interesting not to see any strong disagreement to this particular question and a large percentage of them are finding such systems useful in the role of training. 31% did not give a response either way which could be due to the fact that they need more time in experimenting with such systems within a working environment. In question 8 trainees were asked if they would rather use an expert system to a lecture and the result was that over 81% refuted the idea. This disagreement actually agrees with the principal research objective, where the introduction of an expert system in training is to act as an aid to the training program **and** not to substitute the role of the trainers. This was also reflected in their answer to question 10 which examines whether expert systems should be used as a supporting tool during training courses. 77% agreed with the fact that expert systems for training should be used as an aid tool. Therefore this is considered to be an important achievement towards meeting research objectives.



### 7.3 Trainees response to knowledge base design

Question 9 examined a statement which suggests that using expert systems in the training field complicates the training function. 31% agreement was noted and agreement may have been given by trainees who might have experienced difficulties which were discussed in relation to previous questions. In question 12, 42% of trainees agreed that introducing experts system in other topics of project management will lead to a better understanding of the subject. That could be done by having a comprehensive expert system which includes most topics of project management enabling future trainees to decide on which topic they feel the need for knowledge improvement and to make use of the expert system by choosing that topic.

Again we can see the same scenario in question 13 where a 50% agreement was given by trainees in support of the use of expert system in training in the industrial and educational settings. To question 14, there was agreement of about 31% that expert systems has enhanced their knowledge on the topic while 42% of trainees gave no opinion. The reason for having a large number of trainees with no opinion

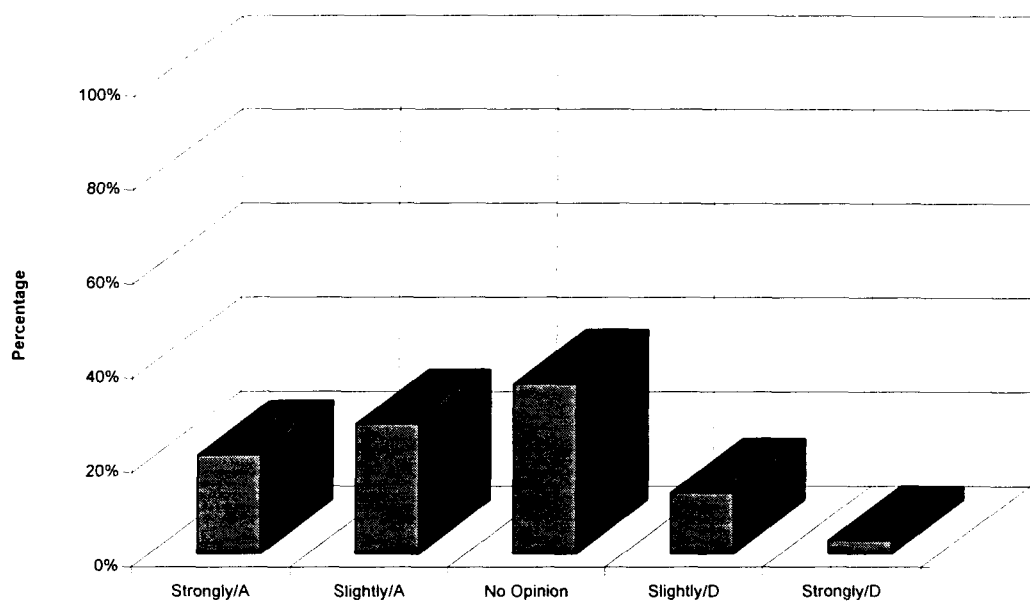
in this particular question can be related again to the time factor and the effect that had on their performance in the evaluation tests.

Responses to questions 13 and 14 supported the idea of introducing more expert systems to improve the quality of learning and training in the field of project management. Question 16 asks trainees if the use of expert systems in training can save time, and 50% had no opinion. This question was ambiguous as to whether time will be saved during the dedicated training period, or over a longer time scale. This may explain the large no-opinion responses. The important issue here is not just to save time but to make full use of expert experience which is one of the main objectives of building an expert system. This experience must have taken time to build during years of work and if trainees make use of it in their training courses then it will no doubt save time eventually.

In Q20 regarding the timing of the training program, about 39% of trainees thought that the timing was good, but a large number did not express an opinion. This was probably due to the undergraduates being unable to appreciate the entire scope of the training programme. Question 23 asked trainees if higher training efficiency can be achieved with such an expert system and about 40% agreed with about 8% disagreeing. Once again there is general support for the use of an expert system. Q24 examined trainees responses to whether they feel more confident in all aspects of contract management after going through the expert system. The first point which can be drawn from their answers is that approximately 58% of them gave no opinion either way which in a way is self explanatory as it would be difficult to suggest that they have learned everything about the subject from one training session.

In question 29 it was important to get a response on the built-in evaluation technique which was applied in the expert system. Trainees were asked if they thought that the

evaluation of trainees after going through a training programme is an important step in achieving higher standards. Over 69% thought that it would be important to introduce an evaluation system at the end of each training program, which was the case in this expert system. Trainees knowledge of contract management was evaluated at four different levels and this was considered to be an important section of the expert system. Q39 in this section asked trainees if they thought that it would be important to learn from expert's experience and 92% agreed that it was important. Training courses should be used to gain as much knowledge as possible from other people's experience in the field.



#### 7.4 Trainees responses to the use of expert systems for training

It would be useful at this stage to see the overall response to this section. In figure 7.4, it can be seen that there is overall support for the use of expert systems in training. In this section it was suggested that using expert systems for training can help trainees by giving them a deeper understanding of the subject and more importantly to gain knowledge from expert's experience.



Having said that it would not be easy to build an expert system that would contain every aspect of work about a specific subject, so it will be of great importance that expert systems are always upgraded as technology advances.

### **7.2.5 Expert system evaluation tests**

In this section various factors of the expert system evaluation tests will be studied. These factors vary from the way the questions in the tests have been structured, to the presentation of the tests. Question 7 starts by asking trainees to give their responses to whether the tests within the expert system were well structured. 39% of trainees thought that this was the case and about 19% thought that the tests were not well structured. This may be related to the length of some of these tests. An alternative would be to have a greater number of tests but a smaller number of questions within each test.

The actual wording of the questions in the evaluation tests could be another factor and this was analysed in question 15. 54% thought that the wording of the questions was sufficiently clear and only 23% faced some difficulties with the wording of the questions, and suggested that it should be improved. This should be considered in future upgrading of the expert system. Q31 examined the fact that all trainees performances can be easily followed through all sections of the evaluation test. Over 46% thought that they could follow their performance in the evaluation test. A scoring system was built in to the expert system to allow trainees to monitor their performance at each question and at each level of the expert system. This is achieved by giving them the result of each question and the correct answer if they failed to get the correct answer.

When trainees complete a section they were given their final result to see how they had performed as an overall assessment. In Q32 trainees were asked if they thought that it was important to define at an early stage their performance level in the evaluation.

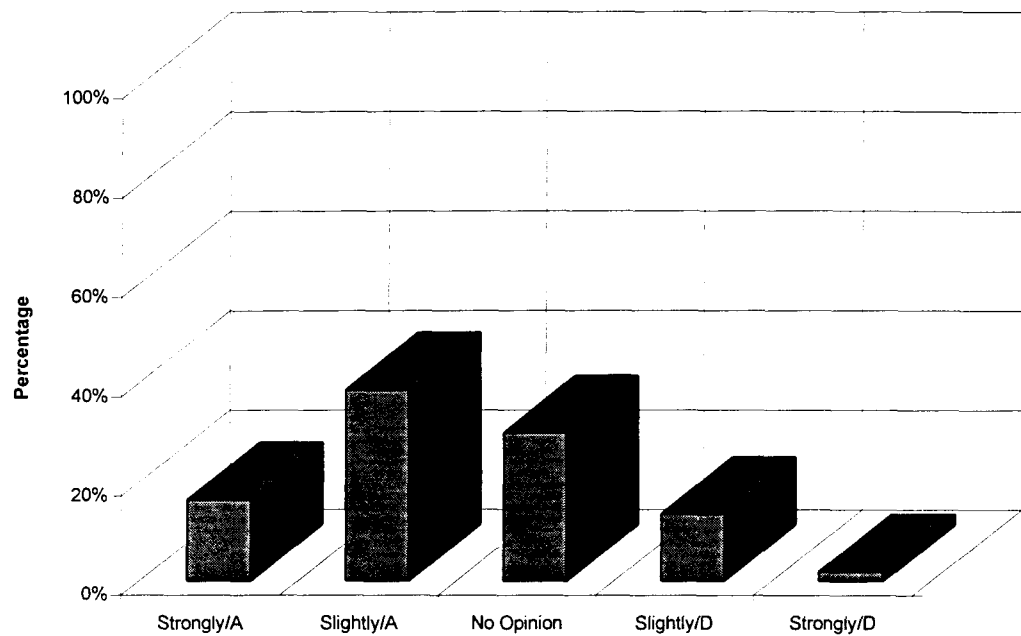


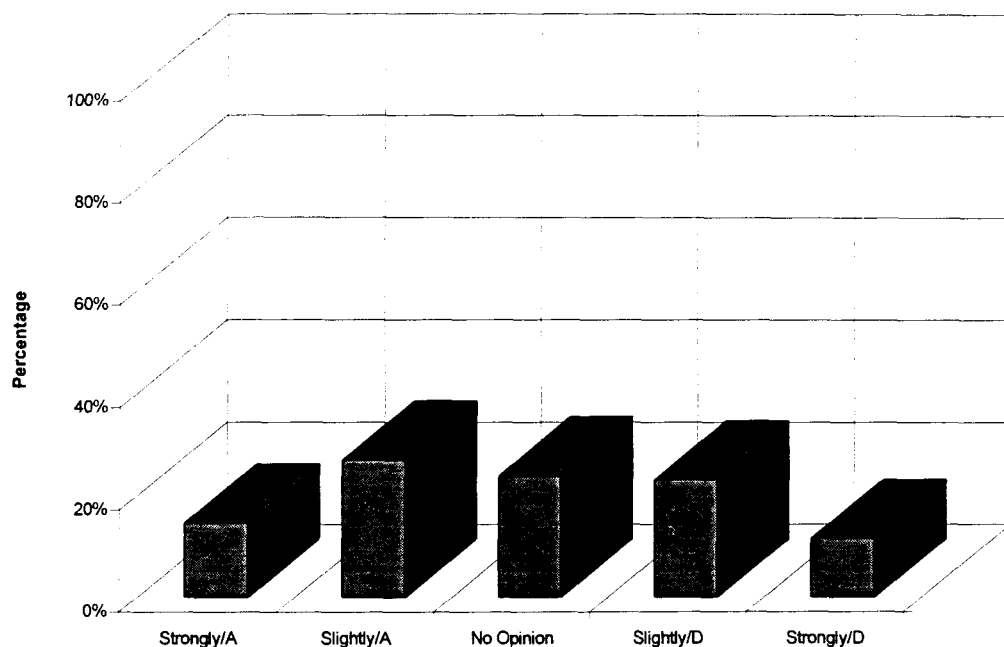
Figure 7.5 Trainees response to expert system evaluation tests

Over 82% of trainees agreed that defining performance during the early stages of training would be important. If they have not performed well in any level, they could go through the display forms in the knowledge base, and build up their own knowledge before starting the test again. In this way they could improve their standards in order to proceed to a higher level in the expert system.

The overall response of trainees to the structure of the expert system evaluation tests can be seen in Figure 7.5 where an average agreement of about 52% was given in support of the current structure of the tests.

### 7.2.6 Trainees knowledge of contract management

This is a general section about trainee's knowledge in contract management. They were asked to give feed back on the amount of knowledge they had about the subject before starting the expert system. Also to find out if the information presented in the knowledge base was sufficient to perform the evaluation tests. In question 11 trainees asked for more information to cover the evaluation tests. This was shown through the response they gave, in which about **39%** of trainees thought that more display forms would be needed to cover all different levels of the evaluation tests. The expert system had been designed such that more information on contract management can be included at any stage.



### 7. 6 Trainees responses to knowledge of contract management

Questions 17 and 30 examined trainees needs for acquiring written information on contract management. Their responses to both question showed that they require to do some preparation on the subject before starting the expert system. This agrees

with the objective of the introduction of the use of the expert system for training. Trainees will perform better if they have some background to the subject whether through lecturing or reading. It must be noted here that the expert system is not intended to replace other methods of training but to contribute to the training program as a whole. The other advantage of having such a system is that trainees can make use of it at any time, and it could also be upgraded with new knowledge on the subject.. **Q38** asked trainees to give their opinion on whether contract management has been explored well in engineering areas. 39% of them thought that more work and training is still needed in this field, and about 15% did not agree with this statement, but as with other branches of construction management there will always be a need for further research. The trainees overall response to the above can be seen in figure 7.6, and no clear trend is visible.

### **7.3 Total questionnaire responses**

Correlation in this section was carried out to examine the relation that might exist between trainees responses on the different sections of the questionnaire groups, and whether conclusions can be a from such relations. In table 7.3 a relationship can be to seen to exist between the trainee's responses to all six sections of the questionnaire. This strong relationship that can be seen to exist among all sections of the evaluation factors was due to the fact that all sections have been chosen appropriately. The relative importance of this correlation that matter and not the actual value of the correlation, 0.511 is considered to be a good correlation. The highest correlation was between the general attitude towards computing (section 1) and knowledge base design (section 3). **An** example of this correlation (0.961) among those sections, can be seen in question 6 on the knowledge base design section and in question 26 on the general attitudes towards computing section, where

trainees responded to both questions by 39% agreement. There seems to be a strong relationship in trainees responses to the knowledge base display form clarity in understanding of the subject of contract management (section 3) and the time saved through the use of the expert system in training (section 4). Their response to these particular two questions shows that if they can follow the information on the display form in the knowledge base then they will save time and work in training. Also we can see from Table 7.3 that the lowest correlation exists between the human computer interaction (section 2) and the trainee's knowledge of contract management (section 6). This low correlation between the two sections could be due to the fact that the human computer interaction section examines the trainee's satisfaction of the use of the screen formats, knowledge presentation and keyboard instructions, while the section on the trainee's knowledge on contract management examines factors such as, whether there is a need for more information on contract management to cover the evaluation tests. Knowledge of contract management should be provided prior to trainees starting the evaluation tests within the expert system.

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Section 1	1.000	0.804	0.961	0.841	0.827	0.743
Section 2	0.804	1.000	0.874	0.958	0.548	0.511
Section 3	0.961	0.874	1.000	0.885	0.750	0.769
Section 4	0.841	0.958	0.885	1.000	0.739	0.689
Section 5	0.827	0.548	0.750	0.739	1.000	0.911
Section 6	0.743	0.511	0.769	0.689	0.911	1.000

Table 7.3 Correlation between trainees responses to sections of questionnaire

(Contract management expert system)

The rest of the other trainee's responses to all different sections of the questionnaire show that a link is present between all other sections.

### 7.3.1 Trainees average response to contract management questionnaire

An attempt was made to find out how each trainee responded to all the questions, in order to relate at a later stage to their performance in the evaluation tests. The trainee's responses are presented on a Likert Scale. A sample of this is shown in figure 7.7. The rest of the figures are given in Appendix C.

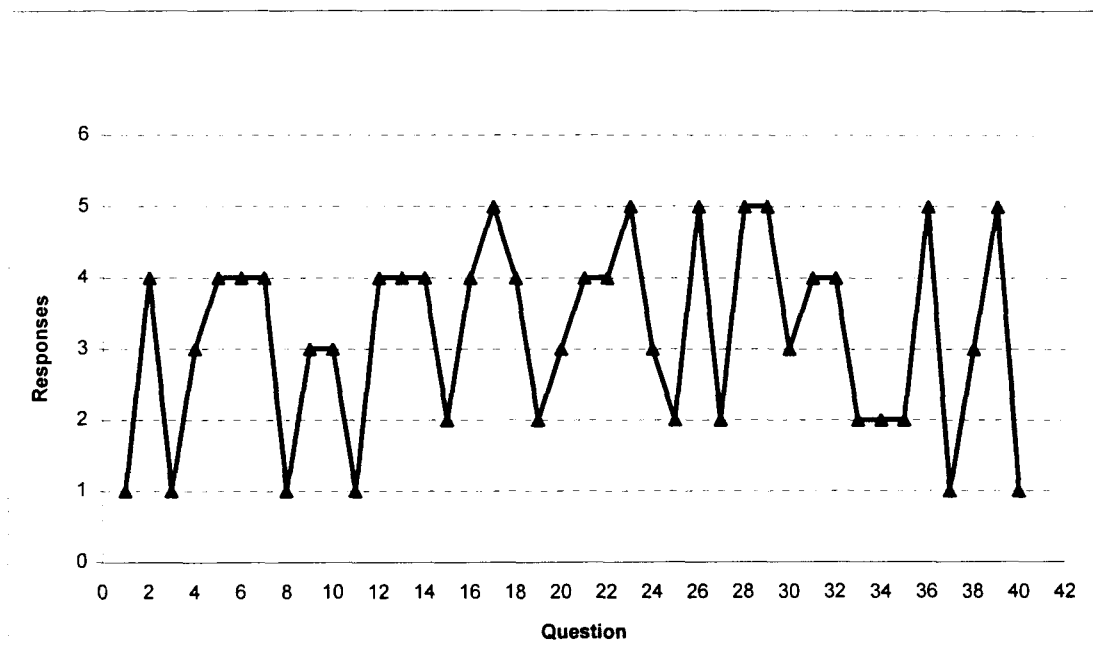


Figure 7. 7 Questionnaire evaluation ( trainee G)

Figure 7.7. shows trainee G's response to each question of the evaluation questionnaire. From the Figure above we can see that trainee G strongly agreed that titles and screen formats were easy to follow in the expert system. The same

response was obtained in question 3 which examined the clarity of the keyboard instruction. Disagreement can easily be seen in question 17, where trainee G was asked to give his view on whether knowledge of contract management was not required prior to using the expert system. In order to get a feel for the overall trainees responses to the questionnaire, the average result is shown below in figure 7.8. From this it can be seen that the plot of the mean lies mainly between a response of 2 and 3, where 2 is the "slightly agree" and 3 is the "no opinion" response.

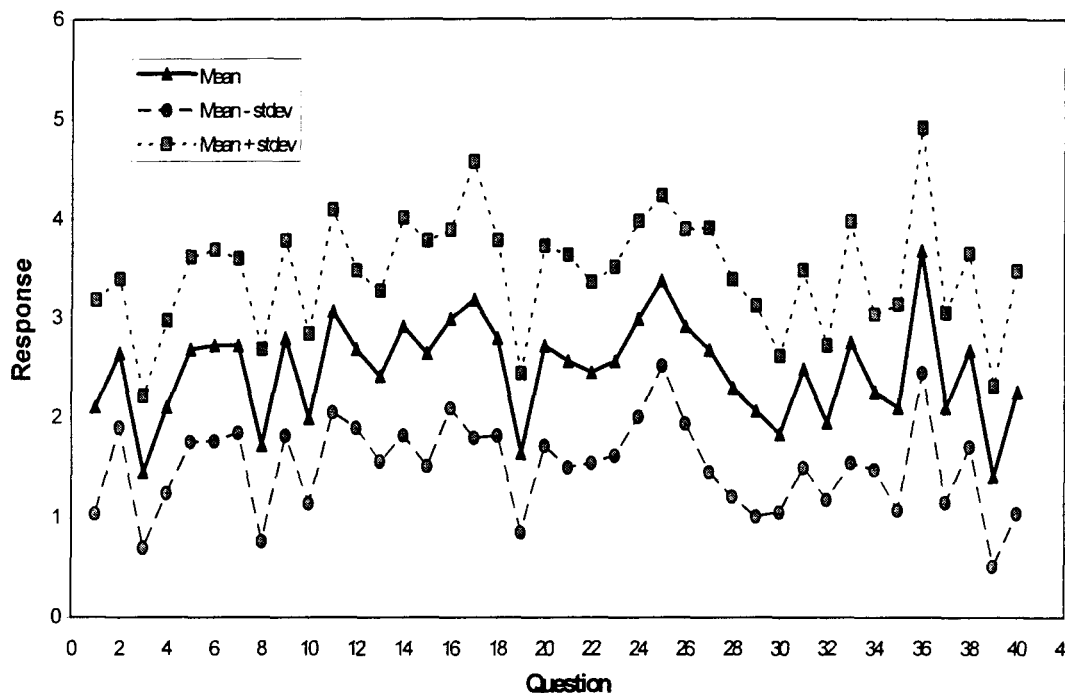


Figure 7.8 Average response of trainees to contract management questionnaire

The highest disagreement can be seen for question 37 which asked trainees if they thought that the expert system was too difficult for them. According to the mean response the average did not think that this was the case. Another observation that can be made from Figure 7.8 is that there was little disagreement on all the different aspects of the expert system. This result is confirmed in figure 7.9, where it can be seen that the trainee's response trend tends to move toward the agreement side and the "no opinion" response has clearly affected the overall result. As was discussed

earlier in the questionnaire sections, it appears that the reason for such a high rate of "no opinion" responses can be related to the experience trainees have in such systems, the way they received knowledge on the subject, and the time it took to go through the expert system. All of these factors should be considered in further development of the expert system.

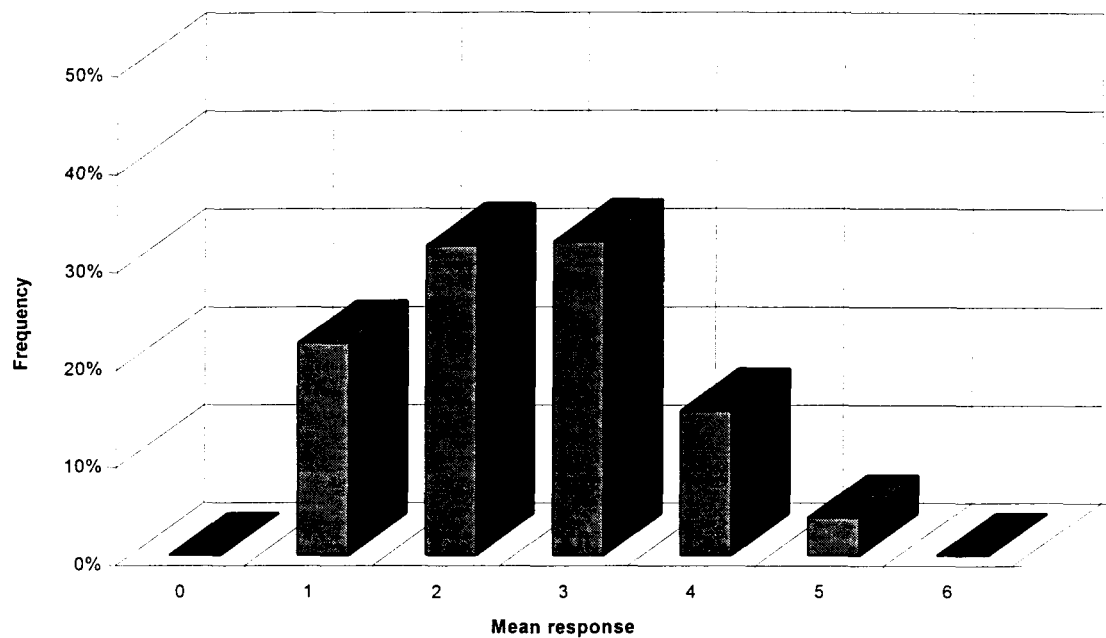


Figure 7.9 Histogram of trainees responses to contract management questionnaire.

### 7.3.2 Total response of each trainee

In order to obtain an overall response to the questionnaire, a final percentage was worked out as described below. The first step was to sum each of the possible choices as shown in table 7.4. The second step was to give an individual mark for the five possible responses. The strongly agree response would be given the highest mark of 5, the slightly agree response a mark of 4, the no opinion response a mark of 3, the slightly disagree response a mark of 2, and finally the strongly disagree a mark of 1. All trainees, total responses were multiplied by each response mark. Trainee



"A's" results are considered below as an example of the procedure that was followed in working out the final marks and percentage to each trainee.

Strongly agree =  $0 \times 5 = 0$

Slightly agree =  $14 \times 4 = 56$

No opinion =  $23 \times 3 = 69$

Trainee	Strongly Agree	Slightly Agree	No opinion	Slightly disagree	Strongly disagree	Q-Mark	Q-Mark (%)
a	0	14	23	3	0	131	66%
b	4	20	11	5	0	143	72%
c	6	22	6	6	0	148	74%
d	3	12	23	2	0	136	68%
e	9	7	14	9	1	134	67%
f	7	15	10	7	1	140	70%
g	6	7	7	13	7	112	56%
h	29	7	2	1	1	182	91%
i	6	10	17	6	1	134	67%
j	21	10	8	0	1	170	85%
k	3	14	17	6	0	134	67%
l	7	11	15	6	1	137	69%
m	12	10	5	9	4	137	69%
n	1	10	17	10	2	118	59%
o	5	16	14	5	0	141	71%
p	5	12	14	6	3	130	65%
q	7	20	12	1	0	153	77%
r	9	20	9	2	0	156	78%
s	4	8	17	6	5	120	60%
t	9	6	12	11	2	129	65%
u	7	14	13	5	1	141	71%
v	3	11	19	6	1	129	65%
w	9	15	13	2	1	149	75%
x	9	14	7	10	0	142	71%
y	25	5	8	0	2	171	86%
z	11	6	7	11	5	127	64%
<b>Average Mark</b>							<b>70%</b>

Table 7.4 Individual trainees final marks.

Slightly agree =  $3 \times 2 = 6$

Strongly disagree =  $0 \times 1 = 0$

Final mark =  $0 + 56 + 69 + 6 + 0 = 131$

Final mark(%) =  $131 \times 100 / 200 = 66\%$ , where 200 is the maximum possible mark.

Higher percentages gained in Table 7.4 indicate higher agreement responses to the use of the expert system for training. The lowest was 56%, the highest was 91% with an average of 70%. There is general agreement that the expert system was an asset to the trainees.

The contract management expert system was carried out by six groups of trainees, (due to limitation of numbers of computers) and the final mark of each group, is given in table 7.5. Although the evaluation tests were carried out by the group, but their responses to the expert system general evaluation was acquired as individuals which is similar to the way in which individual gave their responses to the safety management expert system.

Number of trainees	Group number	Strongly agree	Slightly agree	No Opinion	Slightly disagree	Strongly disagree	Question-naire final mark	Question-naire final mark %
3	<b>Group I</b>	10	56	40	14	0	422	<b>70%</b>
4	<b>Group II</b>	25	41	54	31	9	522	<b>65%</b>
3	<b>Group III</b>	56	27	27	7	3	486	<b>81%</b>
5	<b>Group IV</b>	28	61	68	36	7	667	<b>67%</b>
5	<b>Group V</b>	34	66	64	26	10	688	<b>69%</b>
4	<b>Group VI</b>	28	54	52	23	3	561	<b>70%</b>

Table 7.5 Groups final mark (%).

The average response of the six groups of trainees was 70.3 %. This result indicates trainees satisfaction in using such an expert system for training. Having said that, one should not forget some of the factors that did not have such a high response where trainees have requested further improvement or adjustment to be made and to consider them in future development of the expert system.

### 7.3.3 Expert system evaluation results

The contract management expert system was designed to contain four separate evaluation levels. The general evaluation level assesses the trainee's general knowledge in contract management, and the remaining three levels are the basic, intermediate, and advanced levels. The expert system will present a number of display forms containing the knowledge required at each level. The score gained by a trainee at the end of each level will depend on his or her understanding of the knowledge presented on the display forms.

	<b>General (20)</b>	<b>Basic (30)</b>	<b>Intermediate (30)</b>	<b>Advanced (30)</b>	<b>Final score (110)</b>	<b>Final score (%)</b>
<b>Group 1</b>	16	22	24	24	86	78%
<b>Group 2</b>	10	16	24	18	68	62%
<b>Group 3</b>	8	10	10	11	39	35%
<b>Group 4</b>	12	20	24	8	74	67%
<b>Group 5</b>	10	18	26	14	68	62%
<b>Group 6</b>	12	18	22	26	78	71%

Table 7.6 Group of trainee's expert system evaluation tests scores

The group scores can be seen in table 7.6, where the maximum scores that can be achieved in the general, basic, intermediate, and advanced levels are 20, 30, 30, 30 respectively. Final score percentages were obtained for each group from the total maximum score of 110. Most of the trainees managed to obtain scores above 60%, with the exception of group 3. This low score, as was mentioned earlier, could be the result of not spending enough time on the knowledge display form with the subject information required to perform the evaluation test.

### 7.3.4 Correlation of questionnaire response with expert system evaluation tests

In this section we examine the correlation which exists between the trainee's responses to the questionnaire and their evaluation tests results.

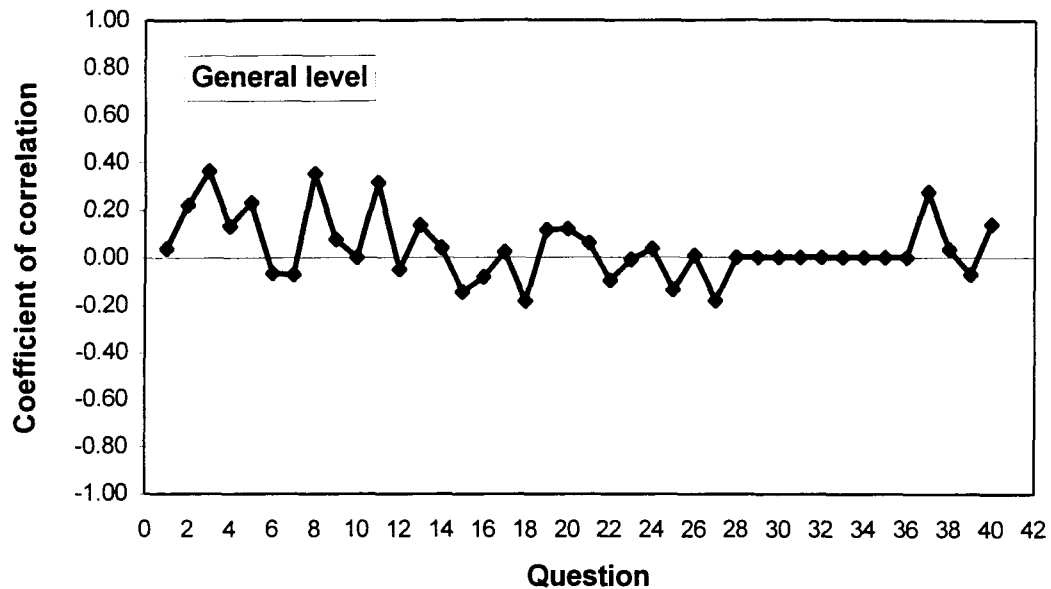


Figure 7.10 Correlation of trainees questionnaire response with their expert system general level evaluation scores.

Studying figures 7.10, 7.11, 7.12, 7.13, 7.14, revealed that almost all the trainee's responses and their expert system evaluation scores at the four levels have little correlation. The lack of correlation here points out that the trainees did not consider the scores they achieved in the expert system evaluation tests when they were giving their views on the use of the contract management expert system.

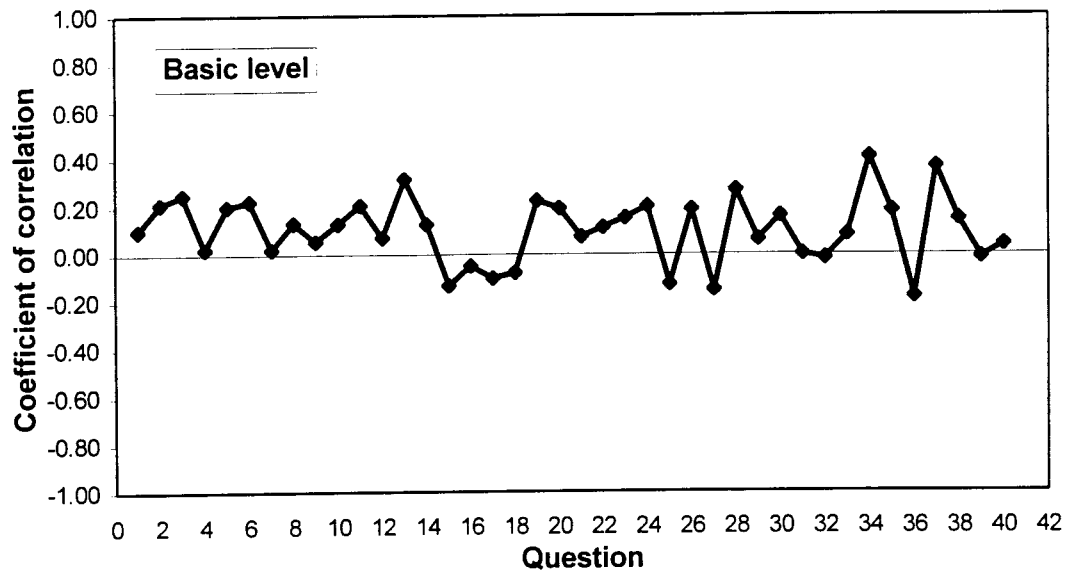


Figure 7.11 Correlation of trainees questionnaire response with their expert system basic level evaluation scores.

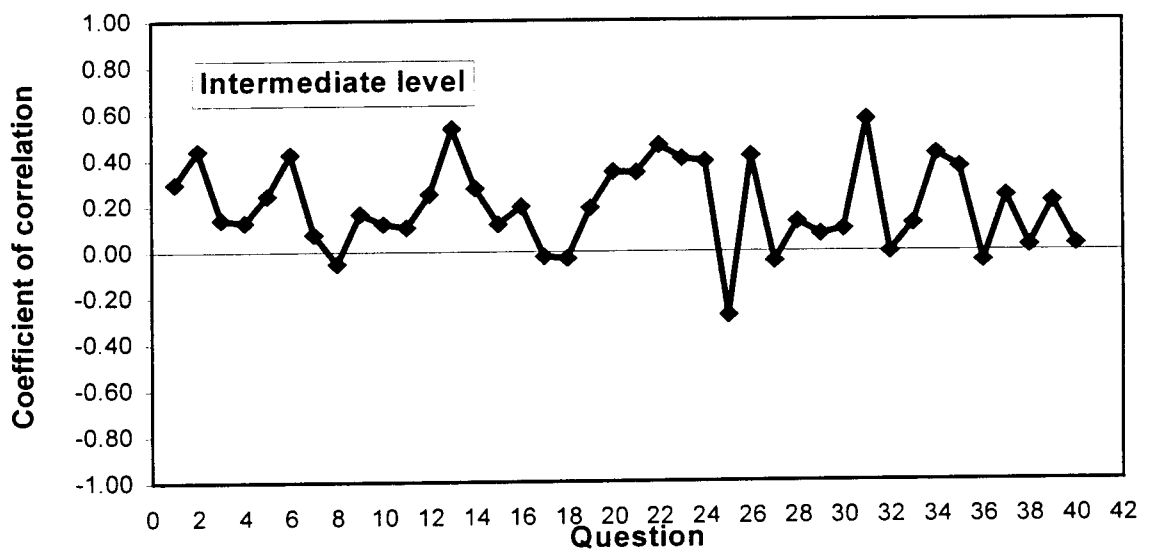


Figure 7.12 Correlation of trainees questionnaire response with their expert system Intermediate level evaluation scores.

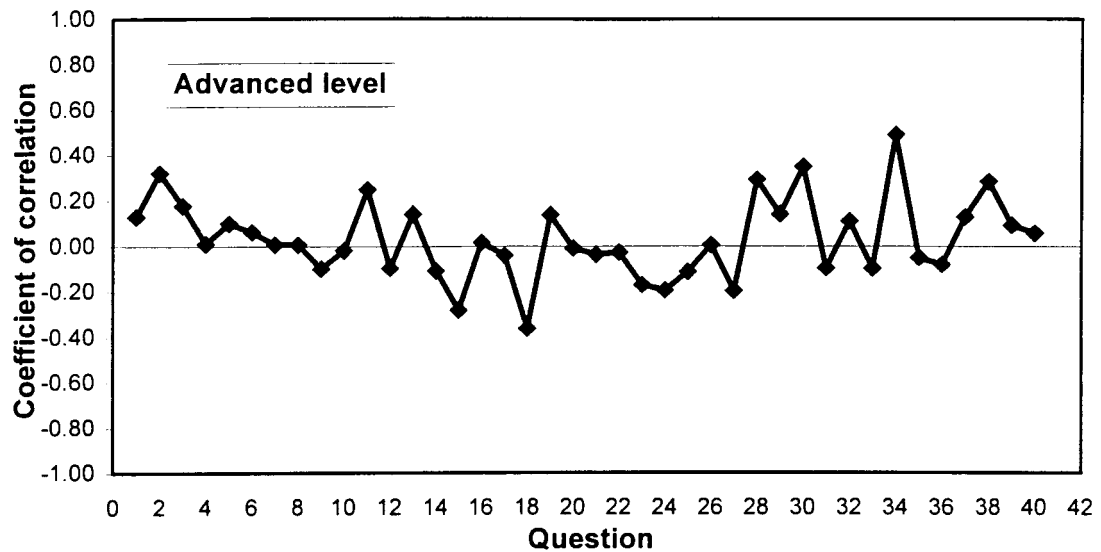


Figure 7.13 Correlation of trainees questionnaire response with their expert system advanced level evaluation scores.

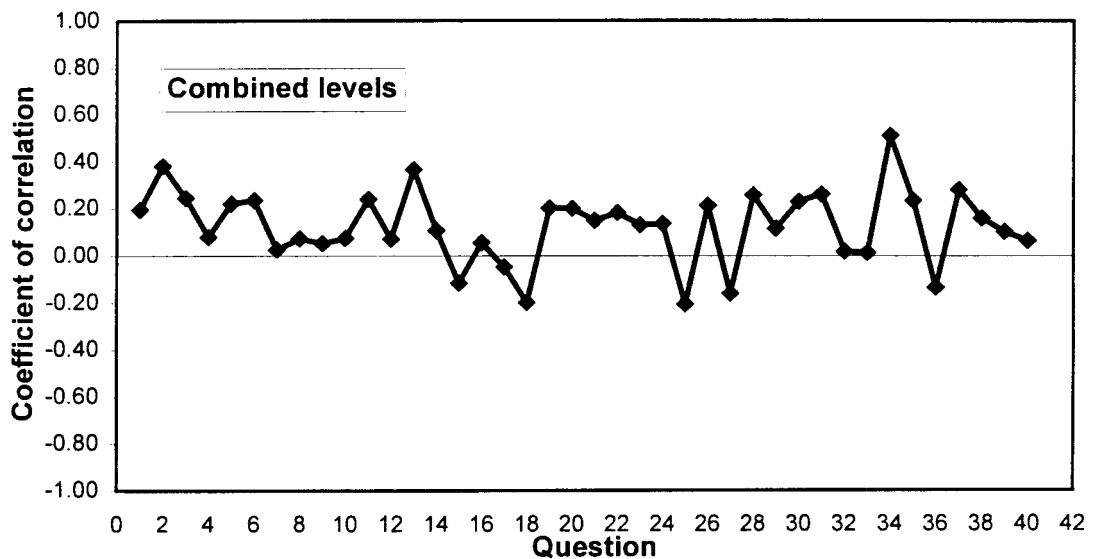


Figure 7.14 Correlation of trainees questionnaire response with their expert system combined evaluation scores.

In order to confirm the results of correlating questionnaire responses with expert system scores which was obtained earlier, another attempt was made by correlating

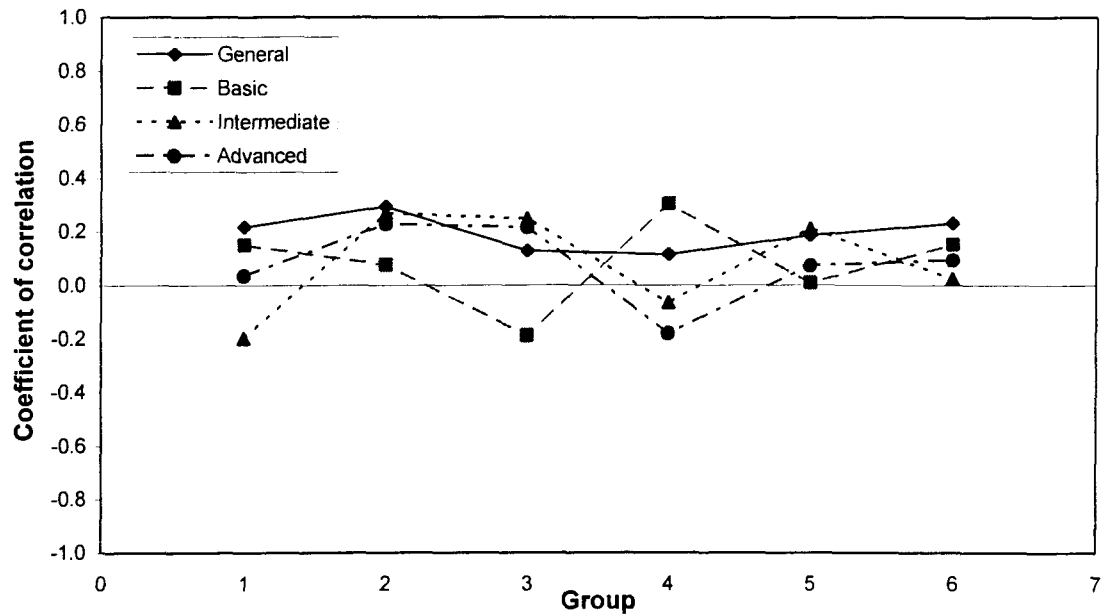


Figure 7.15 Correlation of trainees response of questionnaire sections with their expert system evaluation scores.

trainees responses to the questionnaire sections against their combined expert system evaluation scores. As can be seen in figure 7.15, a similar result was obtained in this case. From all the figures above it is important to point out that whether trainees scores were high or low did not have an effect on the questionnaire responses. This is considered to be a positive point since the average support to the expert system was 70%.

#### 7.4 Safety Management Expert System Tool

This section deals with the analysis of trainees responses to the feed back questionnaire (Appendix E) and the expert system evaluation test scores of the safety management expert system. Percentages of their questionnaire responses to each question can be seen in table 7.7.

Conclusions produced from the questionnaire's six sections as shown in table 7.1 have been obtained from trainees responses to each question. Due to the large number of graphs produced in these sections only graphs which represent trainees response to each section will be presented in this chapter. The rest of the individual questions response graphs can be seen in Appendix F . Questions which have similar responses to the questionnaire contract management expert system analysis will not be repeated in this section. Instead the discussion will be on issues additional to those in contract management.

#### **7.4.1 Attitudes towards computing**

The first question in this section is question 26 which looked at the time and work that would be saved with the use of computers in training. Slightly higher agreement response was seen to exist in this question in comparison to the response gained earlier for the same question. 40% agreement was given by trainees in this case. Trainees were getting slightly more familiar with the idea of using such systems in training after the experience they had with the contract management expert system. There was still a 33% response of "no opinion" as in question 26 in the contract management section. Question 28 examined the fact that there is a need for more effort from both computer science and project management researchers to build more comprehensive expert systems for the construction industry. Again a higher response occurred to what was obtained earlier . This time trainees gave over 77% agreement to that fact, which suggests that trainees are showing interest in the use of such systems in training and seeing more work being done in this area.



Question	Mean	Agreement	Disagreement	No opinion
Q1	2.3	63.3%	16.7%	20.0%
Q2	2.7	50.0%	33.3%	16.7%
Q3	1.3	96.7%	3.3%	0.0%
Q4	2.2	63.3%	6.7%	30.0%
Q5	2.4	53.3%	13.3%	33.3%
Q6	2.8	43.3%	23.3%	33.3%
Q7	2.5	63.3%	16.7%	20.0%
Q8	1.9	76.7%	10.0%	13.3%
Q9	2.4	60.0%	16.7%	23.3%
Q10	1.8	86.7%	6.7%	6.7%
Q11	3.7	10.0%	70.0%	20.0%
Q12	2.7	43.3%	20.0%	36.7%
Q13	2.4	53.3%	10.0%	36.7%
Q14	3.1	30.0%	40.0%	30.0%
Q15	3.4	26.7%	56.7%	16.7%
Q16	3.2	16.7%	30.0%	53.3%
Q17	3.6	23.3%	63.3%	13.3%
Q18	3.2	33.3%	46.7%	20.0%
Q19	1.5	90.0%	3.3%	6.7%
Q20	3.2	20.0%	36.7%	43.3%
Q21	2.9	46.7%	43.3%	10.0%
Q22	2.4	50.0%	13.3%	36.7%
Q23	2.9	33.3%	23.3%	43.3%
Q24	3.4	23.3%	53.3%	23.3%
Q25	3.3	23.3%	36.7%	40.0%
Q26	2.9	40.0%	26.7%	33.3%
Q27	2.5	53.3%	23.3%	23.3%
Q28	2.0	76.7%	6.7%	16.7%
Q29	1.8	80.0%	3.3%	16.7%
Q30	1.7	83.3%	3.3%	13.3%
Q31	2.4	56.7%	20.0%	23.3%
Q32	1.9	80.0%	0.0%	20.0%
Q33	3.8	23.3%	70.0%	6.7%
Q34	2.1	66.7%	0.0%	33.3%
Q35	1.4	93.3%	0.0%	6.7%
Q36	3.2	36.7%	50.0%	13.3%
Q37	2.2	60.0%	13.3%	26.7%
Q38	2.2	76.7%	13.3%	10.0%
Q39	1.4	96.7%	3.3%	0.0%
Q40	2.2	63.3%	13.3%	23.3%

## 7.7 Summary of safety management analysis

Q35 and Q40 shared the same idea, and that is to find out whether trainees felt that computers are needed in education and if they were looking forward to computers taking over the more tasks in both education and the work environment.

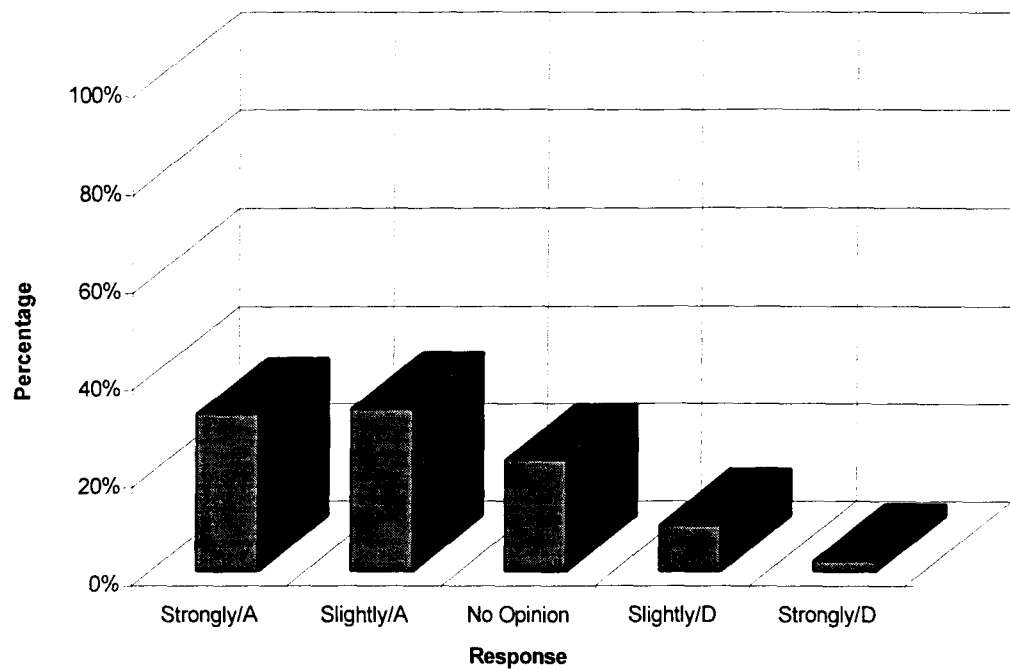


Figure 7.16 Trainees responses to general attitudes towards computing

Responses were 93% and 63% agreement respectively. From the high percentage of agreement that was given to both questions, it could be seen that trainees are responding positively to the use of expert systems whether in education or in work environment and the trainees have agreed to the fact that the role of computers is becoming more important. It would be appropriate at this stage to point out that the average response in this section is in favour of making use of all possible tools that can be offered through the use of computers. The overall response is shown in Figure 7.16 where an agreement response of 60% is observed with a very small percentage disagreement.

### 7.4.2 Human computer interaction

This section examines different aspects of expert system user satisfaction, and includes screen formats, display form design, and keyboard instruction. In question 1 trainees responses were over 63% in favour of the current design of screen formats. A 17% disagreement was also recorded in their response to question 10 which suggests that more could be done to improve screen formats.

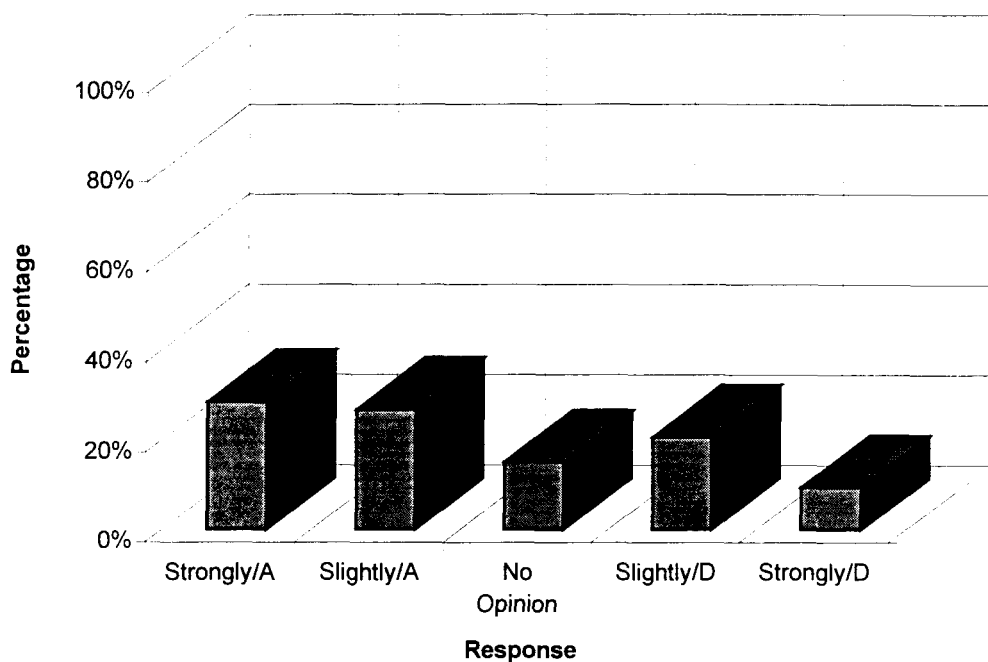


Figure 7.17 Trainees responses to aspects of human computer interaction

It is known that there is not always a best way to design screen formats or keyboard instruction. The most important point is to make sure that instructions are given in a very clear way so they will not be an obstacle to the use of the expert system. If we examine the high percentage of over 97% agreement that was gained in question 3, which looked at the clarity of the keyboard instruction, we will find that this result confirms the response obtained earlier in the same question in the contract management section, where an agreement response of 85% was obtained.

This high agreement in both expert systems suggests that trainees are satisfied with the presentation. **An** overall response is presented in Figure 7.17. It shows that an average of approximately 50% agreement response was given to this section, which again is a similar result to the one obtained in the contract management expert system. It is worth stating again that the display forms seem to hold the key to gaining further support from those trainees who were negative to the use of expert systems. Variations in the presentation of display forms could help those trainees in achieving a better understanding of the subject. Having said that, figure 7.17 also shows many trainees who have managed to grasp the information presented on the display forms within the allocated time.

#### **7.4.3 Knowledge base design**

In the knowledge base design section we will be considering all aspects that have a direct affect on the understanding of the subject (Safety Management) contained in the knowledge base. There are five questions in this section and they will be examined individually. Question 4 was presented to the trainees in order to get their views as to whether information on safety management contained in the knowledge base has covered most of the subject. A response of 63% was in agreement. Some trainees, 7%, have faced some difficulties. It is important to point out that spending more time on the display forms could help those trainees who disagreed on this issue, and bring them up to date on the subject of safety management. One final point here is the percentage disagreement of 7% is about the same disagreement level to the same question in the contract management section.

Analysis of question 6 revealed that 43% of trainees agreed that the knowledge display forms gave a clear understanding of safety management as a subject, this

result can be linked to question 21 in the human computer section where 47% of trainees also agreed that key points on display forms were easy to follow. Both Q6 and Q21 responses suggest that trainees found some difficulties in certain parts of the display forms. This could be related to the size of the information presented to them or more importantly that the time allowed to read and understand was insufficient. Therefore the solution here could lie either in a reduction in the amount of knowledge which trainees have to understand or allowing them more time to read it. The response given in question 19 can be linked with the trainee's responses to questions 6 and 21. They gave 90% agreement in support of doing some reading on the subject prior to using the safety management expert system. This would help them gain a deeper understanding for the evaluation tests . Studying Figure 7.18 provides us with the average trainee's responses to the knowledge base design issues. A 55% agreement was given, which is considered to be an average result.

It is important in the future development of expert systems for training to consider all of the aspects that were discussed in this section and implement any changes that might be required by trainees.

#### **7.4.4 Expert system for training**

Most of the questions in this section are concerned with the different aspects of training quality which are expected to be produced as a result of using the expert system as an aid tool to training. Question 5 asked trainees to give their response on whether such systems can improve their work efficiency. A 53% agreement response was given by trainees, stating that using such a system can improve work efficiency, while about 13% disagreed. The only observation that can be made out of this

response is that no strong disagreement was given and a large number of trainees find such systems useful in the role of training.

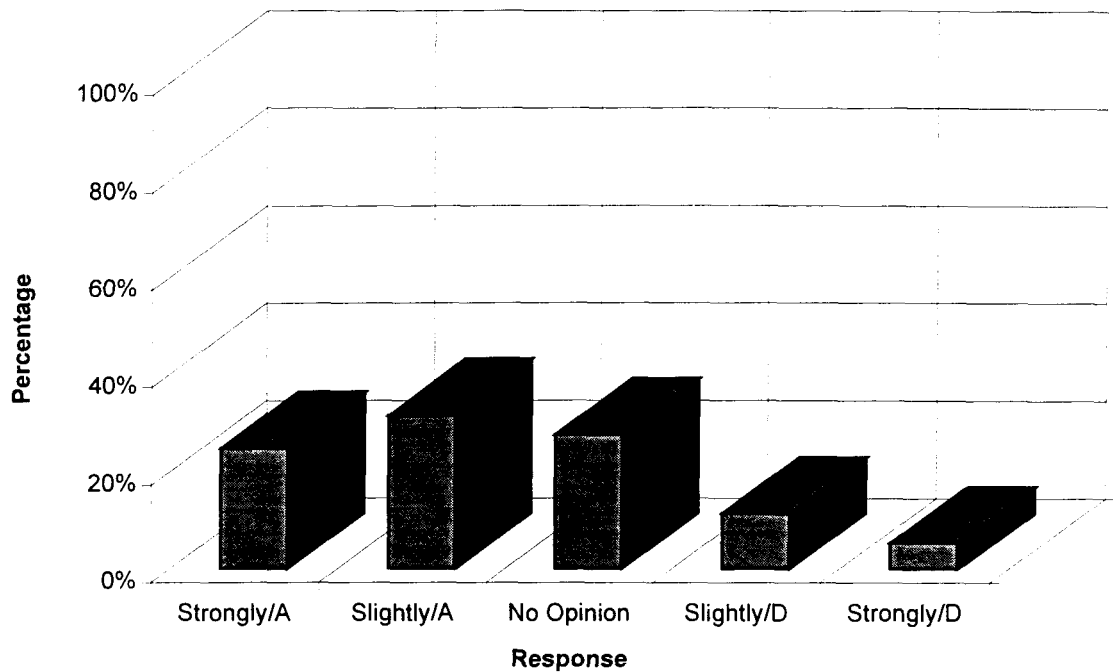


Figure 7.18 Trainees responses to the knowledge base design section

In question 8 trainees were asked to state whether they would rather use expert systems than a lecture and the result was that over 70% agreed to this fact. Although it is an encouraging result and trainees are showing a great deal of more interest in the expert system, the fact remains that the expert system is only meant to be used as an aid tool in training and not to substitute for a lecture or a trainer work. Question 10 tends to emphasise the conclusion that was presented in question 8 as over 87% of trainees thought that using expert systems as an aid tool for training courses was a positive step. What we can conclude from questions 8 and 10 is that trainees are interested in seeing more expert system tools being built for training.

Question 13 resulted in a 53% agreement in support of the benefits which expert systems could provide in education and industrial settings. The help that can be

offered through the use of expert systems will enhance the trainee's knowledge on the subject of safety management. Question 14 received an unusual response of 30% agreement, 40% disagreement and 30% no opinion. The word 'quality' may have been ambiguous to those without an understanding of what quality means. Question 20 asked trainees to give their view on whether the timing of the training program was good, with a 20% agreement. This is in contrast to the 40% agreement for the contract management expert system.

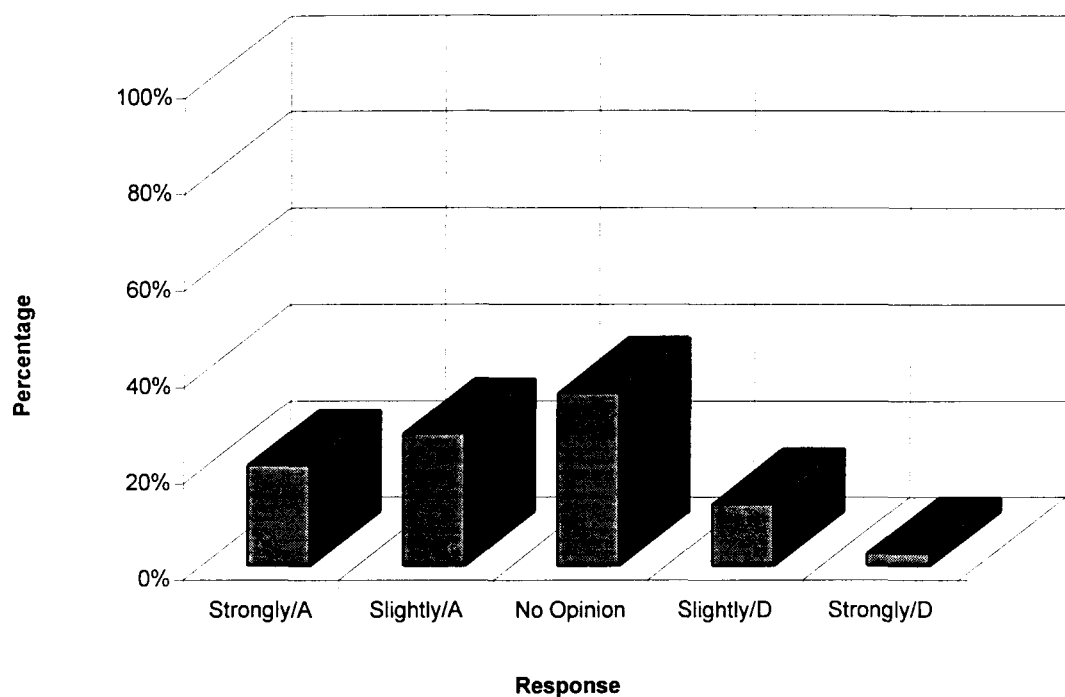


Figure 7.19 Trainees responses to the use of expert system for training

Interestingly, the safety management expert system was attempted before the lectures, whereas for the contract management the sequence was reversed. It is concluded that before an expert system is attempted, it is important that the trainees are provided with some basic knowledge.

The final question, **39**, asked trainees if they thought that it would be important to learn from expert's experience. One of the main objectives of building this expert

system tool is to make use of the expert's experience in the field of safety management and that was the reason for asking such a question. Question 39 resulted in a high agreement of over 96%, which confirms the result obtained earlier for the same question in the contract management section. This result shows that trainees are interested in making full use of experts in the area of safety management. The overall trainee responses are shown on figure 7.19. An average of around 40% of trainees agreed with all the different elements on the use of expert systems for training, and again we notice that a number of trainees are unable to express an opinion. Conclusions discussed earlier in this section suggest that trainees have benefited from the expert system and especially in making use of experts knowledge in this area. The time factor seems to be important as they requested that more time should be allowed to go through such a system.

#### **7.4.5 Expert system evaluation tests**

This section will examine various factors concerning the expert system evaluation tests. Question 7 in this section asked trainees to give their responses as to whether the tests within the expert system were well structured. About 63% of trainees thought that was the case and about 16% gave an opposite response. This was considered to be a better result than the one which was recorded for the same question in the contract management section, and it shows that trainees have followed the design of the four different evaluation tests and this was reflected on their scores. This will be discussed further at a later point in the evaluation tests scores. Although trainees were satisfied with the structure of the evaluation tests, they requested improvement in the wording of these questions and that was obvious from their response to question 15, as it carried a high proportion of disagreement of 57%. Attempts must be made to upgrade the style of wording of the questions in the



evaluation tests in future development, and this could help to improve their performance.

Another question in this section was question 31 which examined whether the trainee's performance can be easily followed through all sections of the evaluation tests and 57% of trainees thought that they actually could. This is considered to be a good result since the system was built in a way which allows trainees to get instant feed back on every question. It will also advise trainees at the end of each test of their final score.

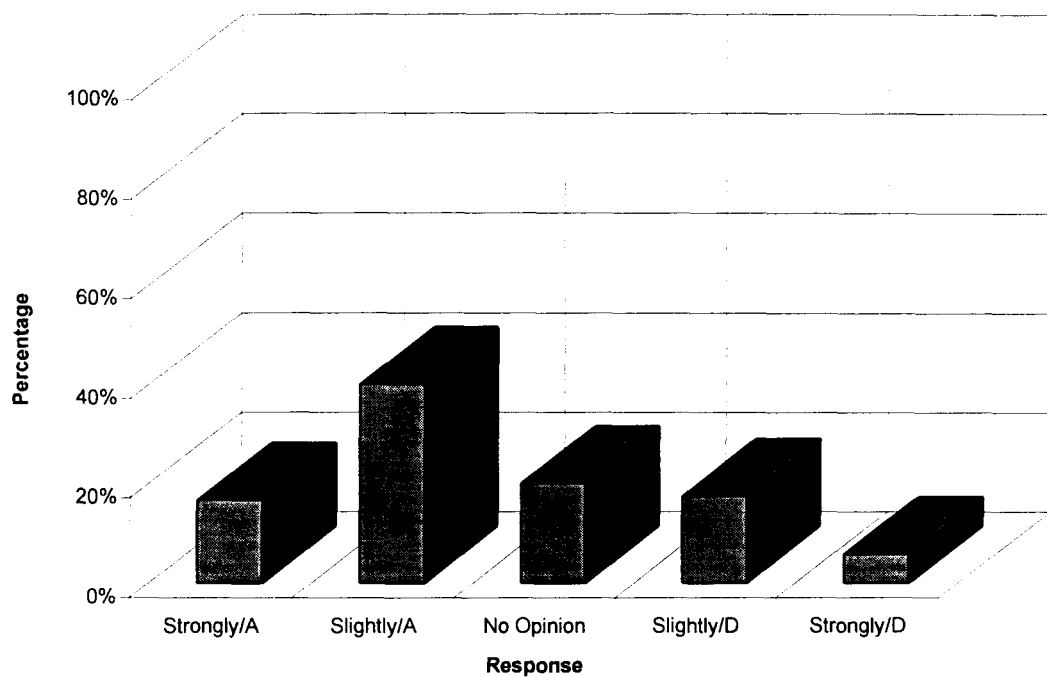


Figure 7.20 Trainees responses to the expert system evaluation tests

On completion of all evaluation tests, a display of scores of the different levels will be provided to help trainees to note their performance at the end of the evaluation program.. Over 80% of trainees in question 32 agreed that defining performance during early stages of training would be important, which is the case in this expert

system tool. It permits them to see how they are performing as they advance in the expert system.

Figure 7.20 shows nearly 60% trainee agreement on the discussed issues of evaluation test structure. From the discussion of these issues one could see that there were not any major problems, except for the wording of the questions contained in the evaluation test. This would benefit from further improvement.

#### **7.4.6 Trainees knowledge on safety management**

This section considers the trainee's general knowledge in safety management, in relation to their knowledge of the subject prior to and after using the expert system. In question 11 trainees were asked if there was a need for more knowledge on safety management in order to complete the four evaluation tests contained in the system. From the trainee's response to question 11 (70% disagreement with the current amount of display forms) it was clear that they required more knowledge in safety management in order to improve their scores. Providing more knowledge is not an obstacle by any means, as the expert system was designed to allow more information to be placed in the knowledge base. The knowledge base can be increased at any stage of the up grading of the expert system. However, there is a limit on the quantity of knowledge that may be transmitted via screen displays. Question 17 and 30 examined the trainee's need for acquiring written information on contract management, a point relevant to the previous comment. Trainees express a desire to do some preparation on safety management topics before starting the expert system, which was also the case in the contract management.. The result produced in both Q17 and Q30) agrees with the objective of the introduction of the use of the expert system for training. The trainees would be expected to make use of all material that is provided in a training course in this subject, and the expert system can provide an

aid in enhancing their knowledge. In **Q38** trainees were asked to give their opinion on whether safety management has been explored well in engineering areas. 77% of them thought that more work and training is still required in the field. That response came as no surprise and most companies are striving to implement more measures in safety management.

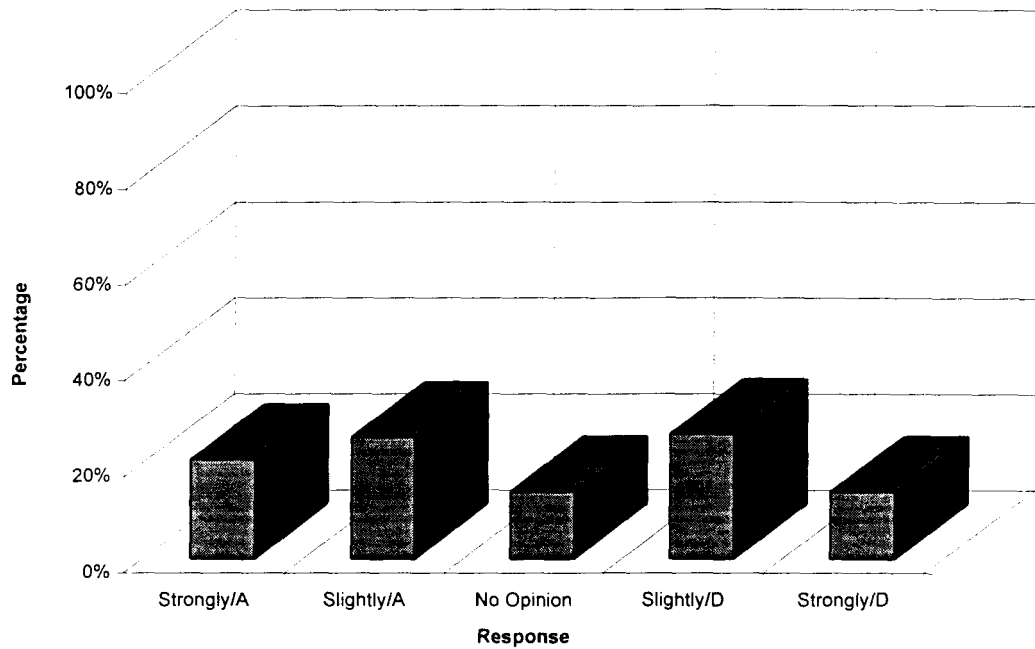


Figure 7.21 Trainees responses to Knowledge on safety management

It is becoming clearer to companies that they can save a lot of time if they have sound safety management policies implemented in their environment. From figure 7.21 we can see that trainees are disagreeing on points concerning the amount of knowledge that was provided and they are requiring more knowledge to be included in the expert system. The point which they raise during the discussion is the preparation that they would like to make prior to using the expert system. All of the discussed points should be taken into consideration on any future upgrading that might be done to the expert system.

## 7.5 Relationship between different sections of questionnaire

This section presents the correlation between the various sections given in table 7.1, in order to study the relationship between trainee's responses to the sections. In figure 7.8 a relationship was seen to exist between trainees responses on most of the six sections of the questionnaire. The highest correlation was noticed between section 2 (human computer interaction) and section 5 (expert system evaluation tests), where a correlation of 0.946 was calculated.

	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6
Section 1	1.000	0.647	0.640	0.744	0.821	0.645
Section 2	0.647	1.000	0.940	0.214	0.946	0.797
Section 3	0.640	0.940	1.000	0.382	0.844	0.835
Section 4	0.744	0.214	0.382	1.000	0.328	0.600
Section 5	0.821	0.946	0.844	0.328	1.000	0.734
Section 6	0.645	0.797	0.835	0.600	0.734	1.000

Table 7.8 Correlation between trainees responses to sections of questionnaire

The analysis of the evaluation tests showed that trainees had some difficulties with the presentation and wording of questions, which can be linked to questions in the

human computer interaction section that had a low agreement response to the information presentation. Therefore one could see that trainees responded in a similar manner in both situations. The key word seems to be presentation, and in order to gain a better response in knowledge presentation on the expert system we must also gain high response in the presentation of the tests.

We can also see from the same table that the lowest correlation to exists between the human computer interaction (section 2) and the section that deals with the use of expert system for training (section 4) . This low correlation could be due to the fact that section 2 focused mainly on specific aspects within the safety management expert system, while section 4 tackles in some ways the general idea of the use of such systems in training. Most of the other sections show that a link is present between different sections of the questionnaire response, and that is due to the nature of evaluation.

#### **7.5.1 Trainees average response to safety management questionnaire.**

In order to investigate further trainees responses in the safety management, an attempt was made to find out how each trainee responded to each and every question of the evaluation questionnaire. Getting a clear picture of individual response can help in the feedback process. It also would be vital when relating individual responses to their expert system evaluation scores.

The individual analysis of trainee responses was carried out using the Likert scale method of presenting data. A sample of these scales is shown in Figure 7.23. The remaining responses can be seen in Appendix F.

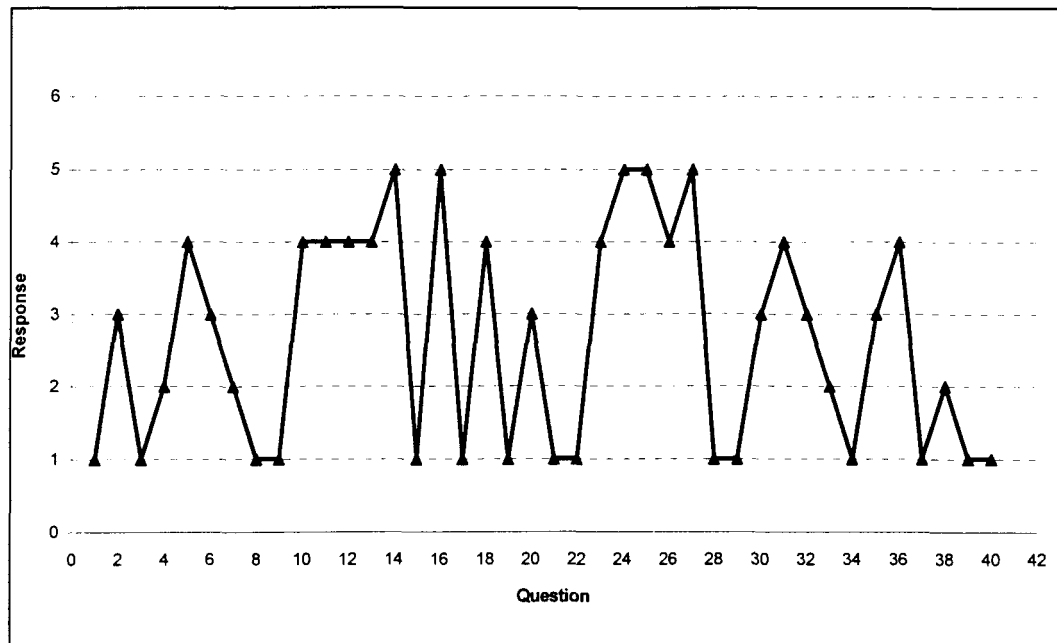


Figure 7.22 questionnaire evaluation (Trainee C)

As can be seen from Figure 7.22 which displays trainee C's response to all 40 question, a high agreement was given to question 1 which examined titles and screen formats and a similar response was given to questions 3, 8, 9, 37, and 40. A slight disagreement on the presentation of the information within the knowledge base can also be seen in questions 2 and 6, which was discussed earlier in the human computer interaction and knowledge base design sections. From the scale it is possible to point out very clearly that trainee C had some difficulties regarding information presentation. This sample is only used here to demonstrate the speed and accuracy of obtaining the trainee's response through the use of this method.

In order to get an overall view of trainee responses to the questionnaire, the mean response is produced in figure 7.23 and from this it can be seen that most of the mean line lies between responses 2 and 3 which are the slightly agree and no opinion responses. The highest disagreement can be clearly seen in questions 11 and 33, which examined the wording of the evaluation section in the expert system, and the need for more information on safety management to cover the evaluation section.

The response here can be explained by the fact that while there is a need for improving the wording of the evaluation questions, there is not a great deal of need for more information on the subject of safety management at the present time. The result obtained are confirmed in Figure 7.24, which shows that the trainee's responses trend tends to move towards the agreement side. It was also noticed that the no opinion response had clearly affected the overall result.

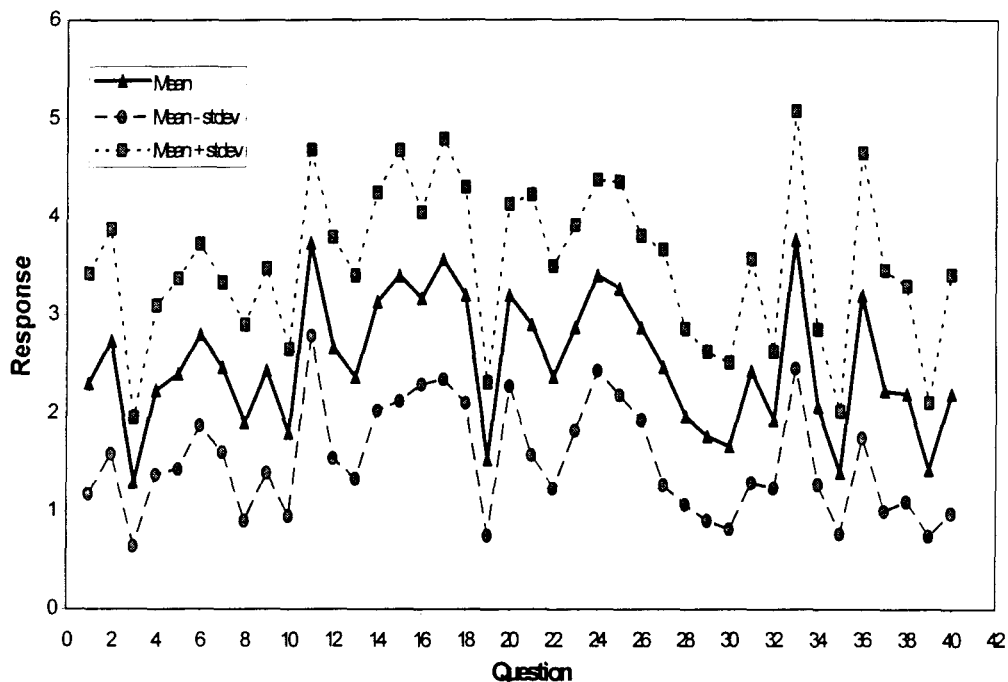


Figure 7.23 Average response of trainees to Safety management questionnaire

### 7.5.2 Total response of each trainees

In order to present each trainee's response to the safety management questionnaire a final percentage should be worked out. This step is carried out by first adding each trainee's five choices of responses separately as shown in Table 7.9. The second move is to allocate individual marks to the five possible responses is by giving the strongly agree response a mark of 5, slightly agree response a mark of 4, no opinion response a mark of 3, slightly disagree response a mark of 2, and the strongly

disagree which would be given a mark of 1. All trainee's final responses out of the five choices will be multiplied by each response's mark. An example of the final mark calculation of trainee A is shown below in table 7.9.

Strongly agree  $28 \times 5 = 140$

Slightly agree  $= 5 \times 4 = 20$

No opinion  $= 2 \times 3 = 6$

Slightly disagree  $= 4 \times 2 = 8$

Strongly disagree  $= 1 \times 1 = 1$

Final mark  $= 140 + 20 + 6 + 8 + 1 = 175$

Final mark(%)  $= (140 + 20 + 6 + 8 + 1) \times 100 / 200$

$= 88\%$ , where 200 is the maximum response mark.

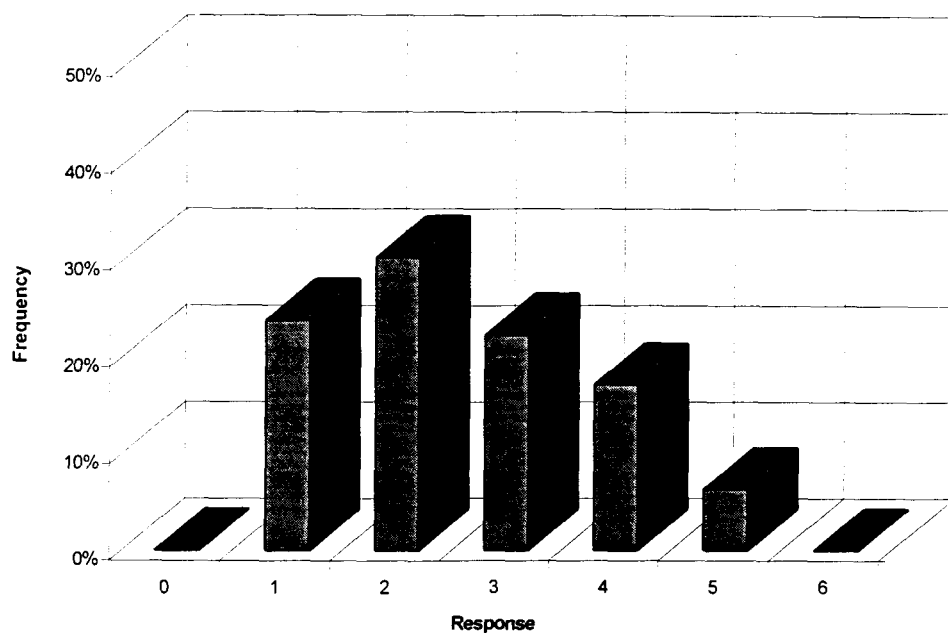


Figure 7.24 Histogram of trainees responses to safety management questionnaire



Higher percentages gained in table 7.9 means higher agreement responses to the use of the expert systems for training. From table 7.9 a final average value of trainees response was calculated to be 70%. This result indicates a level of satisfaction in using such a system for training, and agrees with the contract management expert system average response which was 70.3%. Having said that, one should not forget the various factors that did not gain a high support. Any future upgrading of the safety management expert system should consider the trainee's suggestions.

### **7.5.3 Expert system evaluation results**

The next step in this section is to try and relate the questionnaire's final marks to the expert system evaluation scores that the trainees obtained during the expert system simulation. The safety management expert system was designed in a such way that it contains four different evaluation levels and the scores are given in Table 7.10. The general evaluation level assesses the trainee's general knowledge in safety management. Depending on the score achieved in the general level, the trainee may then proceed to the intermediate level or alternatively be advised to read the relevant display forms on the subject and proceed by starting at the basic level of the evaluation. The remaining three levels are the basic, intermediate, and advanced level. The expert system will present the relevant information on the subject at different parts of the evaluation. The score gained by trainees at the end of each level will depend on the knowledge acquired from the display forms. The maximum scores that can be achieved in the general, basic, intermediate, and advanced levels are 20, 30, 30 and 30 respectively. The expert system will also present trainees with their performance at each level. A total number of 14 trainees managed to obtain high scores over 70% and only 6 trainees scored below 50%, the rest varied between 50% and 70%.

Trainee	Strongly agree	Slightly agree	No Opinion	Slightly disagree	Strongly disagree	Final mark	Final mark (%)
a	28	5	2	4	1	175	88%
b	15	7	6	10	2	143	72%
c	15	4	6	10	5	134	67%
d	5	19	10	4	2	141	71%
e	3	13	15	8	1	129	65%
f	1	24	6	9	0	137	69%
g	11	7	14	7	1	140	70%
h	12	15	6	4	3	149	75%
i	17	13	4	1	5	156	78%
j	13	17	5	4	1	157	79%
k	7	9	11	10	3	127	64%
l	9	15	10	5	1	146	73%
m	10	9	10	8	3	135	68%
n	18	9	9	0	4	157	79%
o	12	6	7	8	7	128	64%
p	0	23	11	5	1	136	68%
q	10	9	5	5	11	122	61%
r	0	14	16	10	0	124	62%
s	10	17	7	6	0	151	76%
t	2	18	8	9	3	127	64%
u	8	2	5	17	8	105	53%
v	0	9	23	8	0	121	61%
w	13	16	5	6	0	156	78%
x	8	10	12	6	4	132	66%
y	11	15	8	6	0	151	76%
z	11	5	12	9	3	132	66%
aa	7	14	8	9	2	135	68%
ab	12	10	10	5	3	143	72%
ac	9	17	8	5	1	148	74%
ad	9	13	9	8	1	141	71%

Table 7.9 Trainees final questionnaire marks

This result suggests that most trainees managed to grasp the subject information and only a minority of trainees faced series difficulties. Those trainees will benefit from the implementation of the points which were raised earlier in the questionnaire

analysis. These trainees could also be identified for extra assistance, thus optimising the training effort.

<b>Trainee</b>	<b>General</b>	<b>Basic</b>	<b>Intermediate</b>	<b>Advanced</b>	<b>Final Score</b>	<b>Final Score (%)</b>
<b>a</b>	20	30	18	26	94	85%
<b>b</b>	12	30	0	0	42	38%
<b>c</b>	16	26	16	26	84	76%
<b>d</b>	18	30	16	16	80	73%
<b>e</b>	18	30	14	0	62	56%
<b>f</b>	18	20	0	0	38	35%
<b>g</b>	18	30	18	24	90	82%
<b>h</b>	18	30	10	0	58	53%
<b>i</b>	18	20	0	0	38	35%
<b>j</b>	16	22	18	0	56	51%
<b>k</b>	20	30	22	14	86	78%
<b>l</b>	20	30	14	30	94	85%
<b>m</b>	14	7	12	14	47	43%
<b>n</b>	20	16	18	0	54	49%
<b>o</b>	16	20	16	0	52	47%
<b>p</b>	16	22	16	24	78	71%
<b>q</b>	16	18	12	22	68	62%
<b>r</b>	18	20	20	20	78	71%
<b>s</b>	18	30	18	24	90	82%
<b>t</b>	18	30	20	26	94	85%
<b>u</b>	12	28	22	0	62	56%
<b>v</b>	18	30	16	30	94	85%
<b>w</b>	16	26	20	18	80	73%
<b>x</b>	16	28	16	0	60	55%
<b>y</b>	18	30	16	30	94	85%
<b>z</b>	20	30	20	0	70	64%
<b>aa</b>	20	30	20	24	94	85%
<b>ab</b>	20	30	20	0	70	64%
<b>ac</b>	16	28	20	0	64	58%
<b>ad</b>	20	30	18	0	68	62%

Table 7.10 Trainees expert system evaluation scores

#### 7.5.4 Correlation of questionnaire response with expert system evaluation tests.

In this section we examine the correlation which exists between the trainees responses to the questionnaire and their expert system evaluation scores. The following figures (7.25, 7.26, 7.27, 7.28, 7.29) clearly represent the four expert system evaluation tests correlated to the trainees final questionnaire marks.

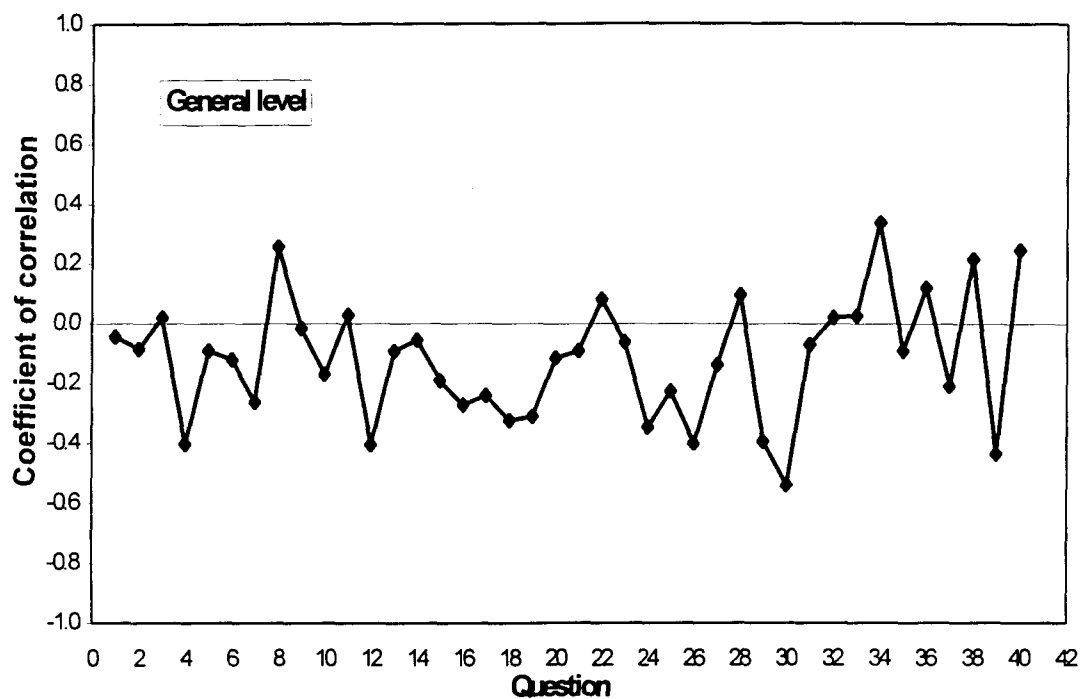


Figure 7.25 Correlation of trainees questionnaire responses with their expert system general level evaluation scores.

As can be seen from the graphs, almost all the trainee's responses and their expert system evaluation scores do not have a strong correlation. The lack of correlation in trainees responses and scores points out that they were not biased in their general attitudes when answering the questionnaire. Trainees did not consider their scores when giving their views on the use of the safety management expert system for training, which in turn explains the independence that exist in the correlation.

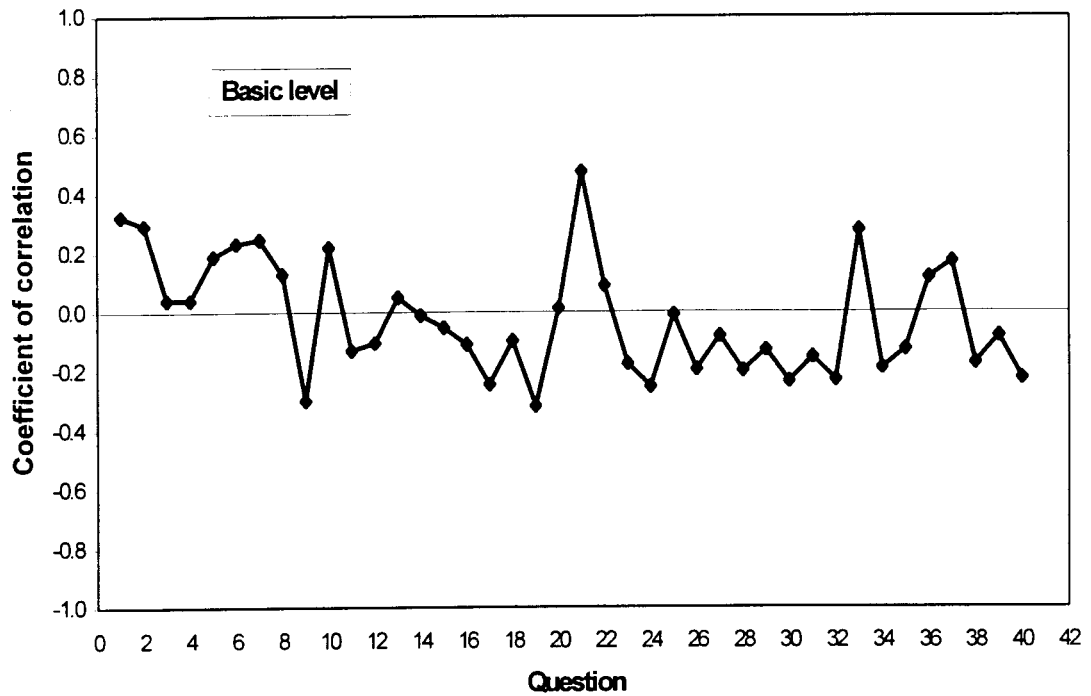


Figure 7.26 Correlation of trainees questionnaire responses with their expert system basic level evaluation scores.

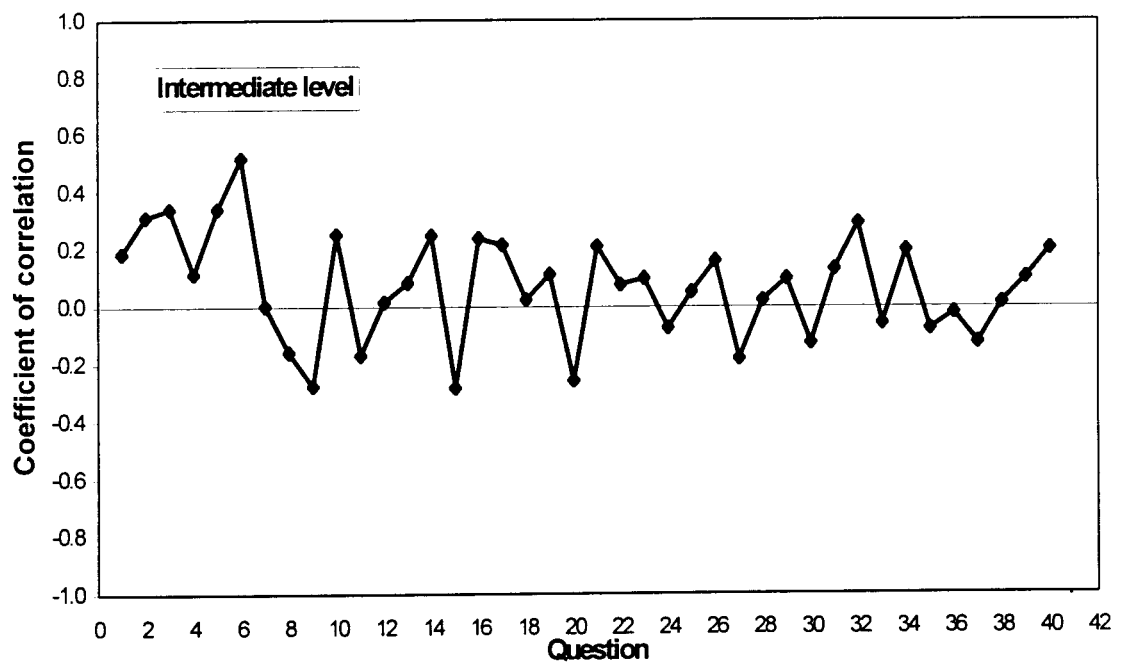


Figure 7.27 Correlation of trainees questionnaire responses with their expert system intermediate level evaluation scores.

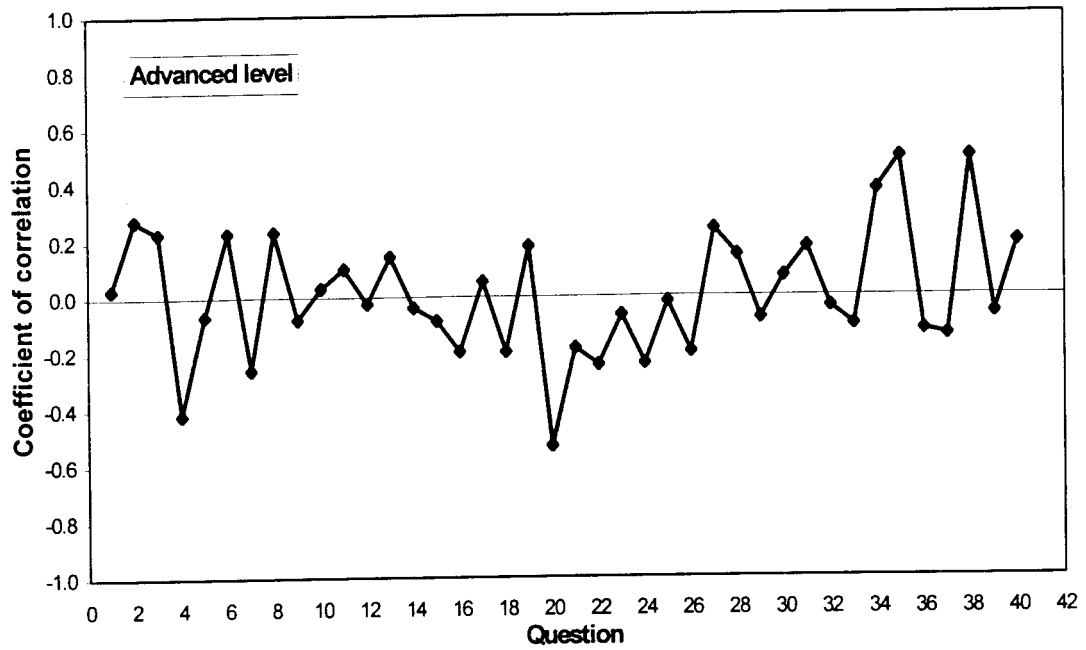


Figure 7.28 Correlation of trainees questionnaire responses with their expert system advanced level evaluation scores.

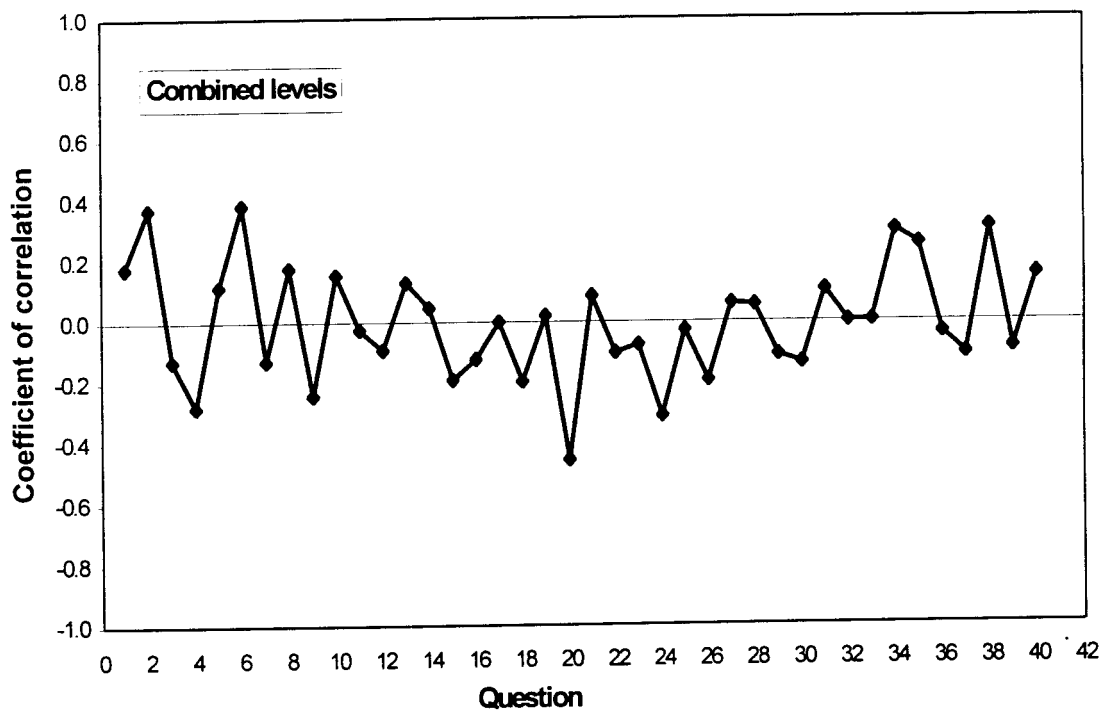


Figure 7.29 Correlation of trainees questionnaire responses with their expert system combined level evaluation scores.

Another attempt was made to confirm the correlation results obtained previously, by correlating the results of trainees responses in the questionnaire sections against their expert system evaluation scores.

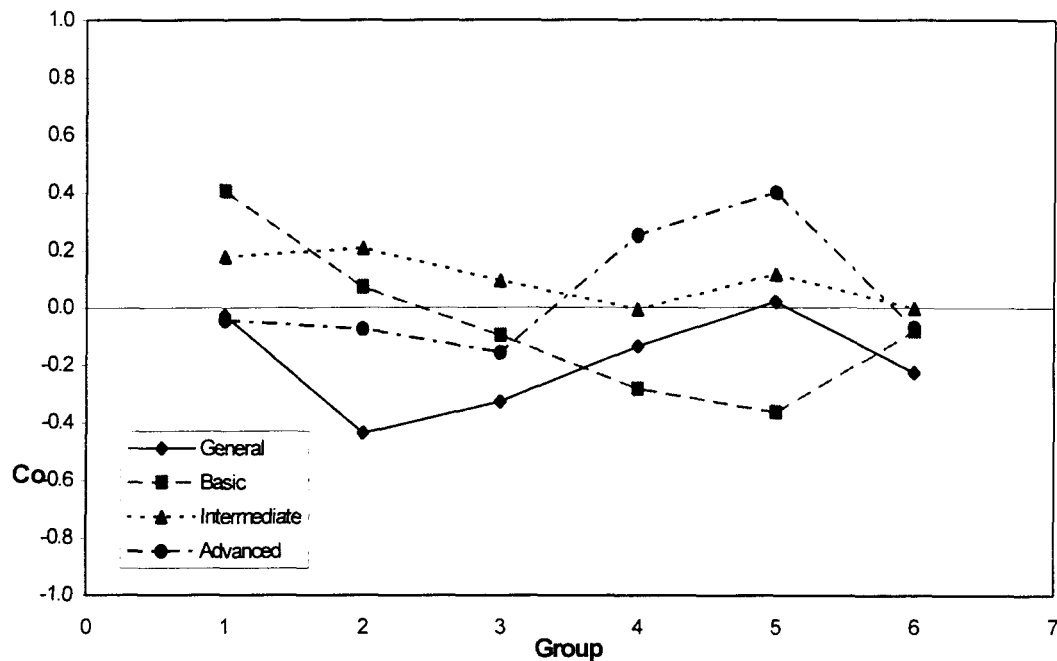


Figure 7.30 Correlation of trainees response of questionnaire sections with their expert system evaluation scores.

As can be seen in figure 7.30, a similar result was obtained in this case, which emphasises the same conclusion that was obtained earlier in the chapter. Studying figure 7.31 revealed that trainees gave a minimum of 50% agreement response even when their expert system evaluation scores were low. For all these figures it is important to point out that whether the trainees scores were high or low did not seem to have a great effect on the questionnaire responses which is considered to be a positive point since the average trainees who approved of the expert system were 70%.

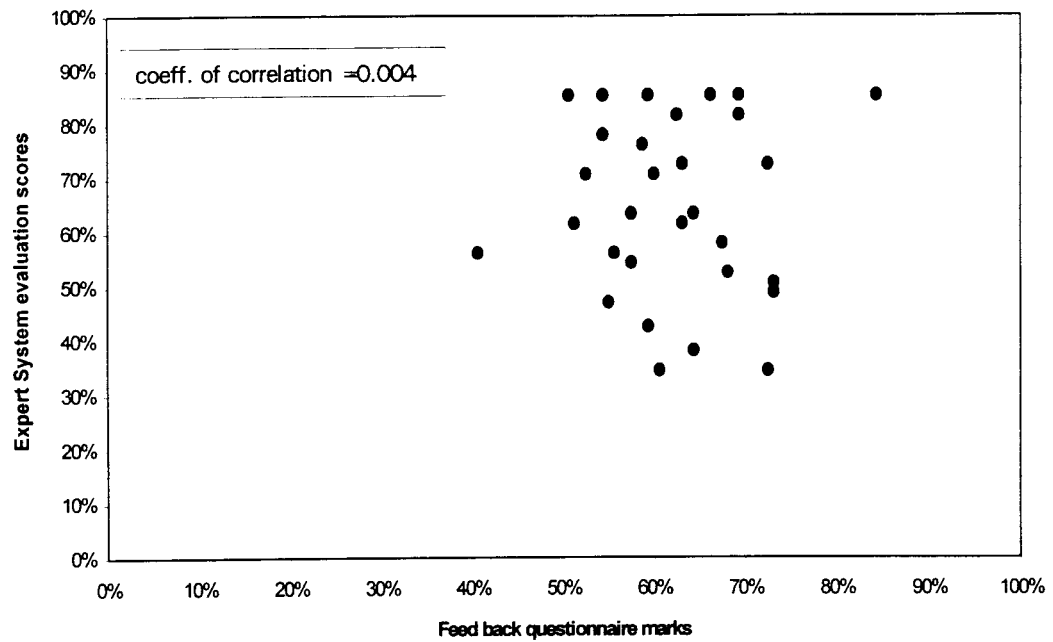


Figure 7.31 Correlation of trainees questionnaire marks and expert system results.

## 7.6 Factor analysis

The factor analysis method (discussed earlier in chapter 5) was applied to the contract and safety management expert system questionnaire (Appendix B & E).

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Q 4	Q 11	Q 1	Q 30	Q 19	Q 22	Q 28	Q 8
Q 5	Q 17	Q 2	Q 38	Q 34	Q 25	Q 29	
Q 7	Q 33	Q 6		Q 37	Q 32	Q 39	
Q 9	Q 40	Q 12			Q 36		
Q 10		Q 15					
Q 13		Q 21					
Q 14		Q 31					
Q 16							
Q 18							
Q 20							
Q 23							
Q 24							
Q 26							
Q 35							

Table 7.11 Questions which weighed most heavily on each factor. (Note Q3 and Q27 did not appear to assort with any of the above).



Since the questionnaire contained 40 questions, a 40 x 40 correlation matrix was generated and a factor analysis was performed. The results of the Orthogonal transformation varimax-solution shows that eight factors were found to exist among trainees responses. Table 7.11 shows the factor loading for each question, with the questions grouped according to the factors upon which they load most heavily. The factor loading describes the weight that each item has on the factor in question. Table 7.13 provides a general description for each of the factors isolated. The factor analysis thus broadly supports the prior grouping of items in the questionnaire which was discussed earlier in this chapter.

Factor 1 shows a large loading which belong to items associated with trainee's feeling towards learning with expert systems. Analysis of trainees responses to individual questions in factor one (see expert system for training, chapter 7) showed that trainees identified that learning can be enhanced through the use of expert systems in project management topics.

Factor 2 has high loading from items that relate to the amount of knowledge which was given to trainees during the use of the expert system (See trainees knowledge , chapter 7). Some of the trainee's responses to questions in factor two suggested that more knowledge on safety and contract management was required prior and during the training exercise. This could be due to the fact that a large number of trainees were presented with new knowledge. McKeachie (1990) has pointed that the new knowledge has to be presented in a way which helps the trainee both to relate it to prior knowledge and to see a clear logical structure within it. On the other hand other trainees thought that no prior knowledge was needed. The knowledge on safety and contract management that was presented in the knowledge base, started with the

basics of the subject and trainees were introduced to deeper knowledge on the two subjects as they advanced in different section of the expert system. This findings agrees with Marton's (1997) argument which suggested that the outcome of learning would depend on the approach (Deep/Surface) of learning that those individuals perceive.

If the prior knowledge is inadequate as was the situations with a number of these trainees then remedial support will be required to allow a firm basis from which to develop understanding. Once the initial grasp of the material is sufficiently firm, further learning involves the elaboration and (further) consolidation of the understanding to include nuances of meaning and additional examples or evidence. Also the need for more knowledge can be related to the fact that learning can be seen as involving a series of stages. Entwistle and Entwistle (1992) have described these stages as taking in new information, relating it to previous knowledge, transforming it through establishing organisational frameworks within which to interpret it, and so developing personal understanding.

Adding more knowledge and information within the display forms in the knowledge base can only enhance the learning process, this fact was actually taken in consideration in the initial stages of the design of the expert system as information can be upgraded at any section of the knowledge base.

Factor three appears to be associated with aspects of human computer interaction and presentation of information and knowledge in the expert system. The factor analysis thus supports the fact that the human computer interface is an important division of judgement, as discussed earlier in chapter 7. Preece (1994) pointed that the design of computer interface is considered to be an important aspect of the human computer

interaction. Bentley (1992) has also explained that when learners use a computer system they react in a similar way to communicating with another person. Which means that the learners they are communicating with are the system designers and programmers who have built the system. As with any human interface the language used, and the way it is used, affect the way that learners feel and react. Bentley (1992) pointed out four key elements of good screen design. The first is the layout; the second is the sequence of action; the third is the knowledge descriptions; and the fourth concerns screen-based instructions.

Factor four and five of the analysis associated all response that relate to the level of learning that trainees has received and whether it was sufficient to make them understand all sections of the expert system. Again the main issue here would tend to concentrate on the amount of knowledge that should be learnt about the subject prior to starting the knowledge base.

Q No.	Factor 1	Q No.	Factor 2	Q No.	Factor 3	Q No.	Factor 4	Q No.	Factor 5	Q No.	Factor 6	Q No.	Factor 7	Q No.	Factor 8
Q4	0.64	Q11	0.78	Q1	0.77	Q30	0.7	Q19	0.83	Q22	0.62	Q28	0.74	Q8	-0.68
Q5	0.67	Q17	0.77	Q2	0.55	Q38	0.75	Q34	0.59	Q25	-8.2	Q29	0.73		
Q7	0.42	Q33	0.68	Q6	0.49			Q37	0.51	Q32	0.64	Q39	0.67		
Q9	0.5	Q40	0.73	Q15	0.63					Q36	0.56				
Q10	0.74			Q21	0.83										
Q12	0.49														
Q13	0.73														
Q14	0.89														
Q16	0.53														
Q18	0.69														
Q20	0.47														
Q23	0.6														
Q24	0.88														
Q26	0.56														
Q35	0.81														

Table 7.12 The factor structure of trainees responses behaviours

The analysis of questions in factor four and five earlier in chapter seven under "trainees knowledge of subject" highlighted a similar conclusion in which trainees

were interested in seeing more material being made available on the subject before starting the training program. This conclusion agrees with Ausubel's (1978) findings as he stated that "the most important single factor influencing learning is what the learner already knows, the introduction of knowledge can be learned in relation to a previously learned background of relevant concepts".

<b>Factor No.</b>	<b>Factor Definition</b>
<b>Factor 1</b>	Trainee feeling towards learning with expert system.
<b>Factor 2</b>	Trainees perceptions as to whether the amount of knowledge available is sufficient to allow them to perform well in the evaluation stages and through the expert system in general.
<b>Factor 3</b>	Trainees concern with the interface of the system (human computer interaction) and its ease of use.
<b>Factor 4</b>	Trainees perceptions on adequacy of background knowledge.
<b>Factor 5</b>	Trainees perceptions on adequacy of background knowledge.
<b>Factor 6</b>	Trainees perception of the design of the knowledge base, and whether it has helped them to monitor their performance more efficiently.
<b>Factor 7</b>	Trainees attitudes towards the idea of learning from experts past experience and the need for more effort from researchers in this field.
<b>Factor 8</b>	Trainees perception of the use of tutor expert systems as a learning aid, as compared with conventional lecture presentation of knowledge.

Table 7.13 Factors definitions.

Factor six appears to be associated with issues on the design of the knowledge base and trainees abilities to monitor their performance during the training program (this was discussed earlier in detail in chapter 7).

Factor seven consisted mainly of loading which belong to items associated with learning from expert experience through computational methods such as knowledge based systems and whether more efforts from experts in the fields of construction management and computer science should be devoted to this area. Trainees are largely in favour of learning from experts in the field and that was shown clearly earlier in this chapter in their responses in table 7.2 & 7.7 to questions on this factor.

The general response of trainees agrees with Dunkin's (1986). research findings, that programmed learning materials and the use of computer-based learning in training has showed a statistically significant advantage in terms of performance, over conventional methods such as lectures. Dunkin carried on to suggest that in conventional learning environment the lecturer controlled the flow of information and set up conditions which directed learning, leaving the trainee with little autonomy.

Although we might agree with Dunkin on the importance of the introduction and use of new technologies in learning, it would be necessary to highlight the fact that the main aim of this research is to introduce the use of technologies and expert system in training as a support tool in training, as it would enhance the overall quality of the training program.

Question 8 stood on its own, being related to the use of expert system as a learning aid, as compared with conventional lecture presentation of knowledge. This fact was backed by trainees response to the final question in factor eight (table 7.12) as

trainees were asked if they thought that expert systems and learning programs could supplement or replace learning through conventional methods. Trainees have overwhelmingly rejected this idea and insisted in using such learning technology as an aid to learning and training.

## **7.7 Summary**

This chapter has highlighted the importance of evaluating the training, as a vital step if any training program was to achieve its objectives. In this chapter, analysis of two different evaluations was carried out (contract and safety management expert systems). Results obtained in both evaluations showed similarities in trainees response. This evaluation looked at different factors in the design of expert system. Undergraduate trainee's have responded to a number of questions with no opinion. This could be due to the lack of work experience and not being able to fully understand the subject. Trainees showed that they are in favour of the use of such systems in training. They suggested that further support to the expert system can be gained if trainees were allowed more time and also allowed to do some preparation on the subject before starting the expert system. This could give them some background on the subject, whether through lecturing or reading. This suggestion by trainees agrees with the expert system development objectives as experts system are not intended to replace other methods of training but to contribute to the training program as a whole. The analysis also revealed that almost all the trainee's questionnaire responses and their expert system evaluation scores at the four levels did not seem to have a strong correlation. Most trainees did not consider the scores which they achieved in the expert system evaluation tests when they were giving their views on the general use of such systems in training. Trainee in both topics of the expert system were about 70% in favour of the expert system. This is considered to be a good result when trainees were newly introduced to the use of the

management training expert system. Factor analysis of the trainee responses has provided broad agreement to the variables chosen in chapter 5.

In this research programme the depth of learning was not investigated because of time constraints and within the context of an undergraduate course, where equal levels of instruction are required, control groups could not be established. This aspect would form an essential part of the extension of the research.

## **Chapter 8 Conclusions and further work**

### **8.1 Introduction**

There is no doubt of the importance of management training in the construction industry. Although there has been a growing recognition of the need for training in many construction companies, controversy still exists as to the extent and quality of training required. One of the elements of this research was to investigate the attitudes of construction companies towards management training and the use of computer technology for such training.

The research started with an attempt to examine different aspects of training management in the context of two different surveys. Both the management training literature survey and the results obtained from the Civil Engineers and Modern Management Practices survey confirmed that there is more work needed on management training to improve the managerial skills within the construction industry if its to meet the criteria which has been specified by the report of the Institution of Civil Engineers (1992). This has led to the introduction of the use of expert systems as a tool in management training programs. The research was finalised by an overall evaluation of the developed expert system model.

### **8.2 Research achievements.**

- The literature review has highlighted the importance of the recognition of individual and company needs. If a construction company was to proceed with training, both individual and organisational needs must be considered and a mutual benefit derived. This can be achieved through the implementation of a human



resource development plan that will analyse the training needs of the company in relation to the company's strategy and also relate this to the needs of the individuals within the company. After identifying the main concepts of training management in human resource development, the current situation on management training and attitudes towards the use of computers within the construction industry was examined through a survey called "Civil Engineers and Management Practices". The management training literature and the survey analysis results revealed that although in recent years there has been an improvement in the way in which management training is perceived amongst different companies within the construction industry, there are still many problems to be solved.

The research also revealed that attitudes to management training are better amongst contractors than consultants. This could be due to the fact that contractors only have management as their process where as consultants are largely technical. It seems that consultants have more to do towards improving their managerial skills. Survey results showed that they are still lagging behind in most aspects of management training.

The answer to that problem could lie with the introduction of new management training policies and making full use of the management training technology which is now available. The contractors on the other hand recognised the value of management training and are making full use of its potential.

The second stage of the survey dealt with the attitudes of construction companies towards the use of computing in performing different tasks. Analysis showed that consultants are more comfortable with and make more use of computers. This is to their advantage as using different computer software and expert systems can only

introduce more efficiency in different construction management fields. The analysis also showed that contractors seemed to be disturbingly uncomfortable with computers, highlighting the fact that there is a need for training in this area. The survey concluded that consultants need to do a lot more towards improving their managerial skills through management training courses. Contractors however proved to have higher management skills than consultants, but they would be advised to improve their computer familiarity as it could further enhance their managerial skills.

- Knowledge acquisition has played an important role in the development of the contract and safety management expert system models in this research. The knowledge acquired had to be reliable to provide the basis for writing the rules of the expert system which was achieved through the use of experts and published material.

- The expert system evaluation procedure that was applied in this research has highlighted the importance of training evaluation as a vital step if any training programme was to achieve its objectives. During the expert system evaluation trainees showed that they are in favour of using such systems in training.

It is also concluded that further support to the expert system can be gained by allowing trainees to make some preparation on the subject before starting with the expert system, as it will give trainees a background to the subject. The trainees suggestion in this case agrees with the objective of introducing such expert systems in management training. Management training expert systems would be expected to contribute to the overall training program.

The analysis also revealed that almost all trainees questionnaire responses and their expert system evaluation scores at the four levels did not have a strong correlation,

which suggests that most trainees did not consider the expert system scores which they have achieved when they were giving their views on the general use of such systems in management training. Trainees in both topics of the expert system were approximately 70% in favour of the expert system. This is considered to be a good result when trainees were new to this concept. Finally, evaluation has shown that common guidelines for expert system development and knowledge engineering have to be tailored to meet the objectives of a particular system.

### **8.3 Recommendation for further research**

The following work can be undertaken in extending and improving the systems :

- Repeating the expert systems evaluation with a larger sample or samples of different professions in the field of construction management. This is required to give more feedback to the expert systems, and it may highlight other factors which need improving.
- Expansion of knowledge base to incorporate more domain knowledge. As knowledge advances in contract and safety management, the expert systems should be upgraded to offer up to date knowledge on the two subjects.
- Expansion of the systems to incorporate different branches of construction project management i.e. risk analysis, project procurements.
- An aspect to be further investigated is the depth of learning achieved through the use of expert system. This would entail a group to be split with some exposed to the

expert system. Comparisons with others would enable quantification of depth of learning.

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# **Appendix A**

A run of the contract management expert system

EXPERT SYSTEM

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  □                      □
  □                      □
  □ EXCONTR1.2 □
  □                      □
  □                      □
  àèèèèèèèèèèèèèèè¥
```

Press ENTER to go to next screen

## EXCONTR 1.2

This project code named EXCONTR 1.2 (for EXpert system for CONTRact management). EXCONTR 1.2 is a rule - based expert system . The expert shell used for this project is CRYSTAL version 4.5. EXCONTR 1.2 is designed to provide a level knowledge on various aspects of Contract Management.

This information is presented in four sections. It is anticipated that you should complete all four sections within 30 minutes.

EXCONTR 1.2 begins by presenting you with a short introduction to the subject followed by an evaluation test, to allow it to assess your present level of knowledge. From there on, EXCONTR 1.2 will display all relevant information before assessing you on the material.

The remaining 3 sections deal with information that would be considered "Basic", "Intermediate" or "Advanced" once an evaluation test has been completed, your score will be displayed.

Press ENTER to go to next screen

## EXCONTR 1.2

To select your choice of answers please follow the steps below:

```

#####
□
□ 1- Move the cursor, by using the arrow keys, to the
□ appropriate box.
□
□
□
□
□ 2- When the correct box has been highlighted press
□ ENTER, so your answer can be stored in the System.
□
□
#####

```

Press ENTER to go to next screen

## CONTRACT MANAGEMENT

[illegible]

Press ENTER to go to next screen

## CONTRACT MANAGEMENT

The following general introduction section contains eight information displays, they are numbered as:- 1-8 to 8-8 .

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#####f
□ Please read through the following displayed information before □
□ starting the General section evaluation on Contract Management. □
□ □
#####Y
```

Press ENTER to go to next screen

## INTRODUCTION

Where services are required which are ancilliary to a company's core business, for example, when undertaking the engineering, procurement and construction of a new facility, the wise owner enters the market place to select and hire a contractor under a set of contractual terms.

This allows the owning company or client to concentrate the efforts of its own staff in the areas of greatest expertise and the owner's objective, which is to have a successful project by safe construction of a good, operable plant at optimum cost, schedule and to the specified quality.

Contracting has an important effect on the owner's success in building a new plant, investment efficiency and competitive position.

Press ENTER to go to next screen

## Introduction (Cont.)

How the contracting is done in a project is known as the contract Strategy, and is one of the most important management aspects of the project.

An owner's engineering contacting approach is normally based on using competitive contracting to select a single contractor to handle the entire project, although occasionally separate contracts may be awarded to associated work such as site preparation, marine facilities and tankage.

As will be seen later, the first choice is the competitively bid lump sum contract, although for schedule, business and other reasons it may be necessary to use the reimbursable cost.

In general, market forces of competition yield the best prices on lump sum projects and the best business and project execution terms on reimbursable cost projects, but in unusual cases, it may prove necessary to place a non-competitive negotiated contract.

Press ENTER to go to next screen

Project Objectives

The supporting objective in contracts management is to enable project management to complete a project which complies with the client's objectives. Once the client's objectives are clearly established they should impact on all decisions made by other people involved in the project - project managers, designers, contractors, sub-contractors, etc.

Overall Objectives

The client may have several reasons for undertaking the project, including:

- \* commercial - e.g. market share, new product, and improved productivity
- \* futuristic - e.g. research and development, and distribution.
- \* social - e.g. improved infrastructure, safety, environmental benefit, welfare.

Press ENTER to go to next screen

Overall Objectives (Cont.)

The need of communication from the feasibility and economic studies, should form the balanced and specific project management objectives.

These objectives are always a combination of:

- The objectives for performance of the completed scheme,
- achieving this performance within a specified cost or budgetary limit and
- getting the project into use by a target date.

Some of the features of these cost, time and quality objectives are that they:

- Inter-relate and can conflict with one another
- Produce decisions which are different in principle and detail (e.g. minimum time versus high performance)
- Can be perceived differently by different people involved in the project
- May change as the project proceeds.

Press ENTER to go to next screen



### Ranking of Objectives

For projects to be managed well it is essential to:-

- (a) Establish the relative importance of objectives by ranking
- (b) Ensure there is wide spread unity of view about the objectives, and, that this view is maintained throughout design, construction and commissioning.

Tolerances should be set for each objective -  
(contingency for cost, float for time and 'space' for quality).

Occasionally, the uncertainty within a project may cause the objectives and their ranking to change during the project.

Where this can be anticipated consideration should be given to sub-dividing the project into phases which permits re-assessment of objectives or choosing a management strategy which is robust to change.

Press ENTER to go to next screen

### Secondary Project Management Objectives:-

On many projects clients set objectives which they do not express directly in terms of cost, time and quality.

Examples include:

- Use of local contractors and/or labour.
- Training of clients' staff.
- Client involvement in project and construction management.
- Minimum client involvement in management.
- Safety (often expressed as part of a quality objective).
- Environmental protection or technology transfer.
- Provision and/or retention of construction equipment by client.

Press ENTER to go to next screen

Secondary Project Management Objectives:- (Cont.)

Such objectives inevitably impact on the main objectives in that they cost money, take time or affect performance (sometimes they will produce savings of cost and time or improve performance).

Achievement of a secondary objective may be very high in the client's criteria for a successful project. To ensure projects are managed well it is recommended that:

- (a) The relative importance of secondary objectives is established.
- (b) Their number is minimised.
- (c) They are properly allowed for when setting the primary objectives.
- (d) They are properly taken account of when setting the management strategy.

Press ENTER to go to next screen

Some other basic principles that normally guide an owner's work include:

- Competitive lump sum prices and reimbursable cost fees are not negotiable.
- Contractor's proposed key personnel, contract terms, technical items, execution schemes and similar items are negotiable.
- Selection of contracting route should optimise project economics balancing investment, completion date and plant operating value.

Press ENTER to go to next screen

## CONTRACT MANAGEMENT

You may now start the general knowledge section evaluation test

Press ENTER to go to next screen

- I. A default by the contractor as performance
- II. The contractor going into liquidation
- III. In both situations

 $\{a\} \quad \mathbb{I}$ 

{b} II

{C} III

The correct answer is

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□ III □

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Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q1) A contract is :

- I. A legal document between two or more persons, their intention being to exchange mutual promises on a particular type of work.
- II. An agreement enforceable by law, between two or more persons to do or abstain from doing some act or acts.
- III. A legal document between two or more persons, their intention being to create legal relations.

a i

d i, ii & iii

g iii

b i &amp; ii

e ii

c i & iii

f ii & iii

please highlight your answer & Press ENTER to go to next screen

Öáááç

◦ ! ◦ Incorrect answer

âáái

A contract is :

- I. A legal document between two or more persons, their intention being to exchange mutual promises on a particular type of work.
- II. An agreement enforceable by law, between two or more persons to do or abstain from doing some act or acts.
- III. A legal document between two or more persons, their intention being to create legal relations.

 $\{a\} \text{ I}$ 

{d} I, II & III

{g} III

{b} I & II

{e} II



CONTRACT MANAGEMENT (General Evaluation Section)

(Q2) How do we assess a contract requirement before it is let ?

Through :

- |   |                     |
|---|---------------------|
| a | Contract policy     |
| b | Contract strategy   |
| c | Contract completion |

Please highlight your answer & Press ENTER to go to next screen

[illegible]

Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q3) Contracting objectives are:-

- i To ensure that work and services are executed to plan.
- ii To meet technical, quality and safety standards.
- iii To make a profit.

- |   |             |   |         |   |     |
|---|-------------|---|---------|---|-----|
| a | i           | d | i & ii  | g | iii |
| b | i, ii & iii | e | ii      |   |     |
| c | ii & iii    | f | i & iii |   |     |

Please highlight your answer & Press ENTER to go to next screen

Öäääç  
° ! ° Incorrect answer  
âääâî

Contracting objectives are:-

- i To ensure that work and services are executed to plan.
- ii To meet technical, quality and safety standards.
- iii To make a profit.

- |     |             |     |         |     |     |
|-----|-------------|-----|---------|-----|-----|
| {a} | i           | {d} | i & ii  | {g} | iii |
| {b} | i, ii & iii | {e} | ii      |     |     |
| {c} | ii & iii    | {f} | i & iii |     |     |

The correct answer is

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□{f} ii & iiii□  
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Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q4) Variations within contracts can only be issued by the client who will normally issue variations to change or to order acceleration of the work.

Can the contractor also request that :-  
a variation be raised in certain situations ?

YES

NO

Please highlight your answer & Press ENTER to go to next screen

```

Oaaaaaaaadadaaaadac
o Oaaaaaaaadac o
o o o o
o o Right Answer o
o o o o
o adadaadai o
adadaadadaadadaadai

```

Press ENTER to go to next screen



CONTRACT MANAGEMENT (General Evaluation Section)

(Q5) The administration and control of a contract, is the responsibility of the sponsor.

True

false

Please highlight your answer & Press ENTER to go to next screen

Öäääç  
° ! ° Incorrect answer  
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---

(Q5) The administration and control of a contract, is the responsibility of the sponsor.

{True }

{false}

---

The correct answer is      èèèèèèèèèèèèèèèèf  
                                 □ True            □  
                                 àèèèèèèèèèèèèèèèè¥  
Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q6) Most forms of contract contain provisions allowing the client to bring to an end the employment of the contractor.  
Generally this can only take place when :-

- I. A default by the contractor as performance
- II. The contractor going into liquidation
- III. In both situations

a I

b II

C IIII

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer

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Most forms of contract contain provisions allowing the client to bring to an end the employment of the contractor.  
Generally this can only take place when :-

- I. A default by the contractor as performance
- II. The contractor going into liquidation
- III. In both situations

 $\{a\} \text{ I}$ 

{b} II

{c} III

The correct answer is

èëëëëëëëëëëë£

□            III            □

àěěěěěěěěěěě€

Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q7) The contractor must carry out all scoped work before he can claim practical completion.

True

False

Please highlight your answer & Press ENTER to go to next screen

Öáááç

◦ ! ◦ Incorrect answer

âááái

The contractor must carry out all scoped work before he can claim practical completion.

{True}

```
{ False }
```

The correct answer is

èëëëëëëëëëëëë

☐ True ☐

àěěěěěěěěěěě¥

Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q8) Reimbursable contract will normally be used when a high level of control is required by the contractor.

True

False

Please highlight your answer & Press ENTER to go to next screen

Öäääç

° ! ° Incorrect answer

âăăí

Reimbursable contract will normally be used when a high level of control is required by the contractor.

```
{ True }
```

```
{ False }
```

The correct answer is

èëëëëëëëëëëë

False

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Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q9) A client's engineering contracting approach, is normally based on using competitive contracting, to select a single contractor to handle the:

- I. Construction stage of the project.

II. Entire project.

### III. Design stage of the project.

a I

b II

C      III

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer

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A client's engineering contracting approach, is normally based on using competitive contracting, to select a single contractor to handle the:

- I. Construction stage of the project.

II. Entire project.

### III. Design stage of the project.

 $\{a\} \quad I$ 

{b} II

{c} III

The correct answer is

éëëëëëëëëëëë

$$\square \quad \{c\} \quad \square$$

àěěěěěěěěěěě€

Press ENTER to go to next screen

CONTRACT MANAGEMENT (General Evaluation Section)

(Q10) In general, market forces of competition yield the best prices on reimbursable cost projects, and the best business and project execution terms on lump sum projects.

True

False

Please highlight your answer & Press ENTER to go to next screen

Öäääääääääääääääääääääç  
° Öäääääääääääääääääääç °  
° ° ° °  
° ° Right Answer ° °  
° ° ° °  
° ääääääääääääääääääääì °  
äääääääääääääääääääääääì

Press ENTER to go to next screen

[illegible]

°Your final result in the General section is:

○

9



6

°Please write the above score on section 2. (Expert System test results)

[illegible]

CONTRACT MANAGEMENT (General Evaluation Section)

[illegible]

° Your performance in the General evaluation test was satisfactory °

[illegible]

Press ENTER to go to next screen

## CONTRACT MANAGEMENT

[illegible]





## CONTRACT MANAGEMENT

1-

### Formation of a Contract -----

A contract is formed when an offer by one party (e.g. a tender) is unconditionally accepted by the second. The keyword is "unconditionally".

This implies full and complete agreement between the parties. An acceptance containing 'ifs' or 'provided that' is not unconditional.

Press ENTER to go to next screen

## Basic Section on CONTRACT MANAGEMENT

2-

### Contract Strategy

Early in the life of any project the client makes major decisions about the technical contents of the project. He also makes decisions about: The nature of the clients objectives-cost, time, quality and the 'secondary' objectives; the roles of the project managers, designers, contractors and suppliers and the extent and boundaries of their duties and responsibilities

The contract strategy is this set of policies and procedures which are selected to implement these management decisions. Selecting a contract strategy thus requires extensive and imaginative planning and major management decisions about the elements shown in :

- \* Project Responsibilities or Work packages.
- \* Organisation of roles and boundaries.
- \* Payment method.
- \* Selection of contractors.

Press ENTER to go to next screen

Some other basic principles that normally guide an owner's work include:

- Competitive Lump sum prices and reimbursable cost fees are not negotiable.
- Contractor's proposed key personnel, contract terms, technical items, execution schemes and similar items are negotiable.
- Selection of contracting route should optimise project economics balancing investment, completion date and plant operating value.

Press ENTER to go to next screen

#### Project Responsibilities or Work packages

How is the totality of work in the project to be subdivided between contractors, designers, project managers etc? The work can be divided geographically, horizontally, vertically or by type of work (examples of the latter would be between design, fabrication, installation, construction or between steel/concrete).

The advantages of a greater number of work packages shrink the risks within each package, permit greater competition and to give greater flexibility for change.

Disadvantages are that fixed costs are increased and the number of interfaces requiring control by or on behalf of the client are rapidly increased.

Press ENTER to go to next screen

Basic Section on CONTRACT MANAGEMENT

7-

Payment Methods

Payment can be based either on prices submitted by or agreed with the contractor or on the actual costs which the contractor incurs.

The main choices are:

PRICE BASED: Lump Sum or Measure and Value - Bill of Quantities, Schedule of Rates.

COST BASED: Target Cost or Cost- Reimbursable

A further choice is whether the tender price should be fixed with respect to inflation or Adjusted using a formula or documentary evidence of price increases. The main factors influencing the choice are the:

Press ENTER to go to next screen

Basic Section on CONTRACT MANAGEMENT

8-

Payment Methods (Cont.)

- \* degree of certainty about the final contract price desired at tender stage.
- \* flexibility required to cope with design changes likely to be encountered during the contract (can they be systematically and equitably evaluated).
- \* contractor's incentive for efficient performance, matched by the client's incentive to provide the contractor with timely information and decisions.
- \* extent of risk likely to be encountered during the contract and the most cost and time efficient way of allocating it.

Press ENTER to go to next screen

Payment Methods (Cont.)

payment may be staged as a lump sums or BoQ. A clear and full specification must be drawn up early in the design stage.

The client makes an early commitment to the whole technical and contractual package. Post contract the client's negotiating position is generally weak. Arrangements may be needed to cover the cost of design done by the contractor in the tender period.

Payment of the management contractor is by fee sometimes plus reimbursable costs. The construction contractors are paid by the client through the management contractor.

Press ENTER to go to next screen

CONTRACTUAL PAYMENT METHODS: KEY FEATURES

LUMP SUM

The Lump Sum is based on a single tendered price for the whole works. Payment may be staged at intervals of time or related to achieved milestones.

The implications are:

- \* Complete, final design at tender.
- \* High degree of tender competition.
- \* Contractor plans efficient use of resources to reduce cost.
- \* Minimum change/variations expected.
- \* No contractual mechanism for price adjustment.
- \* Unsuitable when change is expected, therefore rarely used in engineering construction.
- \* Price may include high level of financing by contractor.
- \* Price includes risk contingency - likely to be high.

Press ENTER to go to next screen

## COST REIMBURSEMENT

Based on payment of actual cost plus a separate Fee for overheads and profit. This may be a fixed fee or a percentage of actual cost. The contractor's cost accounts are open to the client (Open book Accounting). Payments may be monthly in advance or in arrears.

Implications of this type are:

- Allows early contractor involvement with low level of design .
- Final price depends on extent to which risks materialise and efficiency of contractor.
- Zero or low financing charges since costs and revenue are closely matched
- Allows client participation in Contract Management.
- Allows contractor input to design.

Press ENTER to go to next screen

## MEASURE AND VALUE

A Bill of Quantities can be used where items of work are listed with estimated quantities.

In UK. building and civil engineering standardised item descriptions and limits to the work included in the item, have been drawn up in 'Standard Methods of Measurement'.

Contractors then tender rates against each item. Payment is usually monthly and is derived from measuring quantities of completed work and valuing at rates in the tender, or using new rates negotiated from tender rates.

A Schedule of Rates may also be used where prices are tendered against unit quantities, with increased risk to the contractor.

Press ENTER to go to next screen

## CONTRACT MANAGEMENT

You may now start the Basic knowledge section evaluation test

Press ENTER to go to next screen







CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q3) Contract management is about:-

- I. Ensuring ethical/legal & good practice
- II. Appraising variations and assessing the risk to project
- IV. Evaluating work excuted and making payment schedule
- III. All of the above

- |   |    |   |     |
|---|----|---|-----|
| a | I  | c | II  |
| b | Iv | d | III |

Please highlight your answer & Press ENTER to go to next screen

Öáááç  
° ! ° Incorrect answer  
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-----  
Contract management is about:-

- I. Ensuring ethical/legal & good practice
- II. Appraising variations and assessing the risk to project.
- IV. Evaluating work excuted and making payment schedule
- III. All of the above

- |     |    |     |     |
|-----|----|-----|-----|
| {a} | I  | {c} | II  |
| {b} | Iv | {d} | III |

-----  
The correct answer is

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□ {d} □  
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Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q4) Contracting objectives are:-

- i To ensure that work and services are executed to plan.
- ii To meet technical, quality and safety standards.
- iii To make a profit.

a	i	d	i & ii	g	iii
b	i, ii & iii	e	ii		
c	ii & iii	f	i & iii		

Please highlight your answer & Press ENTER to go to next screen

Öáááç  
° ! ° Incorrect answer  
âááái

Contracting objectives are:-

- i To ensure that work and services are executed to plan.
- ii To meet technical, quality and safety standards.
- iii To make a profit.

{a}	i	{d}	i & ii	{g}	iii
{b}	i, ii & iii	{e}	ii		
{c}	ii & iii	{f}	i & iii		

The correct answer is

èèèèèèèèèèèèèèèè  
 □ {b} □  
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Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q5) Which of the following contract payment methods are considered to be unit price based :-

- |      |                    |                  |   |          |
|------|--------------------|------------------|---|----------|
| I.   | Lump sum           |                  |   |          |
| II.  | B.O.Q              |                  |   |          |
| III. | Cost-reimbursable  |                  |   |          |
| IV.  | Schedule of rates. |                  |   |          |
|      | a                  | I, II, & III     | b | III      |
|      | c                  | II & IV          | d | III & IV |
|      | e                  | I, II, III, & IV |   |          |

Please highlight your answer & Press ENTER to go to next screen

Öäääç  
° ! ° Incorrect answer  
âääâî

Which of the following contract payment methods are considered to be unit price based :-

- I. Lump sum
- II. B.O.Q
- III. Cost-reimbursable
- IV. Schedule of rates.
- |     |                  |     |          |
|-----|------------------|-----|----------|
| {a} | I, II, & III     | {b} | III      |
| {c} | II & IV          | {d} | III & IV |
| {e} | I, II, III, & IV |     |          |

```

The correct answer is      àèèèèèèèèèèèf
                          □ {c} □
                          àèèèèèèèèèèèY
                        Press ENTER to go to next screen

```

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q6) One of the most important functions in project management contract is the managing contractor's role. It is to be responsible for preparing the overall construction programme and work packages, and steering these through design stage, recommending/appointing (sub)contractors and securing their smooth integration.

True

False

Please highlight your answer & Press ENTER to go to next screen

```
Oaaaaaaadadaaaaadadaaadac
o   Oaaaaaaadadaaaaadadaaadac   o
o       o                               o
o   o   Right Answer               o
o       o                               o
o   adadaaaaadadaaaaadadaaadai   o
adadaaaaadadaaaaadadaaaaadadaaadai
```

Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q7) What must we have available in a project in order to let a contract :

- I. Scope of work.
- II. Time frame.
- III. Deliverables from client.
- IV . Spesification and drawings
- V . Cost / prices
- |   |           |   |                  |
|---|-----------|---|------------------|
| a | I, IV & V | b | I & II           |
| c | III & V   | d | I, II & IV       |
| e | IV & V    | f | All of the above |

Please highlight your answer & Press ENTER to go to next screen

[illegible]

Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q8) A contract is formed when an offer by one party (e.g. a tender) is conditionally accepted by the second.

True

False

Please highlight your answer & Press ENTER to go to next screen

```
Öááác
° ! ° Incorrect answer
âááái
```

A contract is formed when an offer by one party (e.g. a tender) is conditionally accepted by the second.

{ True }

```
{False}
```

The correct answer is

```

èèèèèèèèèèèèèèèèè
□      {False}      □
àèèèèèèèèèèèèèèèèè

```

Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q9) Is it true to consider the following as a tendering procedure for selecting contractors ?

- I. Continuity.  
II Two stage.  
III. Negotiated.

YES

NO

Please highlight your answer & Press ENTER to go to next screen

```
Öáááç
° ! °   Incorrect answer
âááái
```

Is it true to consider the following as a tendering procedure for selecting contractors ?

- I. Continuity.  
II Two stage.  
III. Negotiated.

{ YES }

 $\{\text{NO}\}$ 

The correct answer is

```

èëëëëëëëëëëëëëëëf
□      {YES}      □
àëëëëëëëëëëëëëëë¥

```

Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q10)

True

False

Please highlight your answer & Press ENTER to go to next screen

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Oaaaaaa
o  Oaaaaaa
o  o
o  o Right Answer
o  o
o  aaaaaa
aaaaaa

```

Press ENTER to go to next screen



CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q11) The method by which a contract is carried out is termed:

- I. Contract policy
- II. Contract strategy
- III. Contract terms

a I                      b II                      c I, II, III  
d I, II

please highlight your answer & Press ENTER to go to next screen

Öäääç  
° ! ° Incorrect answer  
âääâî

The method by which a contract is carried out is termed:

- I. Contract policy
- II. Contract strategy
- III. Contract terms

{a} I                      {b} II                      {c} I, II, III  
{d} I, II

The correct answer is

èèèèèèèèèèèèèèèè  
 □ {b} □  
 àèèèèèèèèèèèèèèèè

Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q12) Contract strategy will have an influence on the following :

- I. Project investment
- II. Return on investment
- III. Construction safety
- V. Plant operability

a	I	b	I, II	c	I, V
d	I, II, III, V	e	III	f	II, III

Please highlight your answer & Press ENTER to go to next screen

```
Öäääç
° ! ° Incorrect answer
ääääî
```

Contract strategy will have an influence on the following :

- I. Project investment
- II. Return on investment
- III. Construction safety
- V. Plant operability

{a} I	{b} I, II	{c} I, V
{d} I, II, III, V	{e} III	{f} II, III

The correct answer is

```
eèëëëëëëëëëëf
□      {d}      □
àèëëëëëëëëëëY
```

Press ENTER to go to next screen

CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q13) Reimbursable contract will normally be used when a high level of control is required by the contractor.

True

False

Please highlight your answer & Press ENTER to go to next screen

```
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° Öääääääääääääääääääç °
° ° ° ° ° ° ° ° ° °
° ° Right Answer ° °
° ° ° ° ° ° ° ° ° °
° ääääääääääääääääääì °
äääääääääääääääääääääì
```

Press ENTER to go to next screen



CONTRACT MANAGEMENT (Basic Evaluation Section)

(Q15) Large organisations would accept that a contract exists if provided as a :

- I. Company order
- II. Form of agreement
- III. Letter of acceptance

a I                      b II                      c III

Please highlight your answer & Press ENTER to go to next screen

Öáááç  
° ! ° Incorrect answer  
âááái

-----  
Large organisations would accept that a contract exists if provided as a :

- I. Company order
- II. Form of agreement
- III. Letter of acceptance

{a} I                      {b} II                      {c} III

-----  
The correct answer is                      èèèèèèèèèèèèèèèèf  
    □ {b} □  
    àèèèèèèèèèèèèèèèè¥  
Press ENTER to go to next screen









## CONTRACT MANAGEMENT

The following Intermediate section contains 14 information display forms, they are numbered as:- 1-14 to 14-14 .

```

=====
[ Please read through the following displayed information before
[ starting the Intermediate section evaluation on Contract Management
[
=====

```

Press ENTER to go to next screen

Intermediate Section on CONTRACT MANAGEMENT

1-

(Administration Issues)

Notifying the contract

Many public organisations and the larger private organisations prefer the written evidence that the contract exists to be in a signed 'Form of Agreement'.

Two other procedures are used:

\* Company Order.

The prime purposes of this is often to introduce the contract into the Client's accounting and administration systems. Consequently, the Client's project staff must take care to keep it in identical terms to the contract.

\* Letter of Acceptance.

This may be worded as an unconditional acceptance. Therefore, it should include full reference to all documents, dates, Contract Price.

Press ENTER to go to next screen

## Commercial Security Issues

### Bonds

There are four main types of bonds in common use on engineering contracts:

#### Tender or Bid Bond

The bidder undertakes to maintain his offer unaltered and open for acceptance during a specified period. If the tenderer defaults he or his surety will pay the Client the full amount stated in the bond. They are mostly used in overseas contracts and typically may be for 1% or 2% of the Contract Price.

#### Performance Bond

The Contractor, after award of the Contract, undertakes to 'punctually, truly and faithfully perform and observe all his obligations under the Contract'. This bond is usually required in the form of a guarantee by an approved surety

Press ENTER to go to next screen

## Commercial Security Issues

### Bonds

#### Repayment Bond

When the Client makes advance payments he may require a bond from the Contractor to undertake payment of any moneys which remain unearned.

#### Plant Performance Bond

Client may require a stated sum of money if the plant fails to achieve the stated performance.

Press ENTER to go to next screen

Commercial Security Issues (Cont.)

Retention

This is a specified sum of money held back by the Client from each monthly certificate of payment due to the Contractor. Its purpose is to provide against defective work and to ensure the Contractor has a financial incentive to carry out necessary repairs and complete small items of work.

Thus retention can be regarded, particularly in the building industries, as a routine safeguard for minor problems. In the offshore oil industry retention at 10% is quite common and is often preferred to a performance bond. Clients should consider the relative financial benefits of bonds as against retention. In many cases the contract price will be lower if the contractor is asked to provide a bond instead of retention.

It is not unusual to convert from retention money to a retention bond at completion of the work and release of part of the retention.

Press ENTER to go to next screen

Commercial Security Issues

Contract Period, Extension of Time and Liquidated Damages

Contract Period is the time specified by which the Works must be executed in accordance with the Contract. Some events entitle the Contractor to an Extension of Time of the Contract Period. (e.g. Client delays, Variation orders, exceptionally adverse weather.)

Liquidated Damages is the amount of compensation to be paid by the Contractor to the Client for a failure to complete within the Contract Period (including Extensions of Time). The amount must be specified in the Conditions of Contract and must be a genuine pre-estimate of the loss likely to be suffered by the Client. The amount specified can be limited to a sum less than the full estimate of damages. Penalties are not enforceable in Common Law countries.

If liquidated damages are not specified, the Client may become entitled to terminate the Contract on the grounds of breach of an essential condition of the Contract.

Alternatively, or in addition, he can seek to recover the actual damages.

Press ENTER to go to next screen

## Controlled Changes to Contract

### Variations

All standard forms of contract contain a clause allowing the client to vary or change the work done under the contract. Without such a clause the contractor would be entitled to refuse to make any alteration in the work.

This variation article defines the powers to issue variations and defines the meaning and scope of variations.

Variations can only be issued by the client who will normally issue variations to change the work or to order acceleration of the work.

The contractor can request that a variation be raised, for example where there is a need to carry out work not included in the original workscope.

Press ENTER to go to next screen

## Uncontrolled Changes to Contract - Claims:

Contracts can be both large and complex, involving a number of separate organisations carrying out work over a long time span and often where design was not complete at tender stage. A claim could be described as the demand for something due, an assertion of a right to something.

### Types of Claim

Claims can be grouped under the following headings:

- Contractual claim
- Extra contractual claim
- Ex gratia claim
- Claims made by the client

Press ENTER to go to next screen

Uncontrolled Changes to Contract

Types of Claim

Claims can be grouped under the following headings:

\* Contractual claim

Where the matter is covered within the terms of the contract, but where the contractor and client cannot reach agreement. Normally due to differing interpretations of the terms of the contract.

\* Extra contractual claim

A claim of right which would be enforceable by law but is not covered within the contract e.g. where client breaches contract, where no provision is made in the contract, misrepresentation, etc.

\* Ex gratia claim

A claim having no legal foundation but which warrants consideration on hardship grounds, or on moral grounds.  
When an ex gratia payment is made it does not assume liability by the client.

Press ENTER to go to next screen

Uncontrolled Changes to Contract

Assessing the value of claims

If it is assumed that the work will not go as planned then it is possible to ease the problem of assessing the value of some areas of claims by anticipating them in the tender documentation e.g. by including schedules of prices for plant and labour that could be used to cost claims.  
It should be noted that the original contract rates may not be appropriate for pricing a claim for disruption or the uneconomic use of labour in an acceleration situation.

Claims Settlement

The authorisation of claims must be set at an appropriate level in the client organisation.  
For example, substantial claims settlement should be presented to tender boards or endorsement, especially ex gratia claims.

Press ENTER to go to next screen

Completion of the contract and work

The contractor must carry out work necessary whether in drawing or specifications or not before he can claim completion.

Close out process:

Contract close out is a formal procedure which should ensure that:

- \* the scope of work is complete,
- \* the final account is agreed,
- \* variations, amendments and claims are made,
- \* the release of any retention,
- \* the guarantee period is complete,
- \* document retention or disposal is properly executed.

Press ENTER to go to next screen

Completion of the contract and work

Certificates

Acceptance Certificate

The contractor notifies the client that the work is physically complete which will result in a certificate of acceptance of the work from the client.

Completion Certificate

The completion certificate is signed by both the client and the contractor at the end of any guarantee period.

Contract Close out Certificate

This is issued by the client for the contractor's signature and confirms that all moneys due to the contractor have been paid.

Press ENTER to go to next screen

Completion of the contract and work

Continuing Liabilities

A contractor has certain liabilities at law even after formal completion of a contract. These are under the following:

Sale of Goods Act 1979,  
Supply of Goods and Services Act 1986  
Latent Damage Act 1986  
The Tort of Negligence

as well as general liabilities under the contract including taxes, patent and proprietary rights and insurance liabilities.

Press ENTER to go to next screen

Dispute Resolution

The contract must state how disputes will be resolved and under which country's law the contract will operate. It should be remembered that there are 2 distinct and separate legal systems in the UK, English and Scottish, which have different attributes and processes.

There are three primary means of dispute resolution:

Litigation,  
Arbitration,  
Alternative Dispute Resolution (ADR)

Litigation

The following comments relate to the English legal system. Litigation may also involve the use of Expert witnesses. To reduce costs the Official referee can order the exchange of expert witness reports before the case is held.

Press ENTER to go to next screen

## Intermediate Section on CONTRACT MANAGEMENT

14-

### Arbitration (Cont.)

This is the process of settlement of any dispute by an arbitrator, who is appointed to settle a dispute of any type. A key factor being that the arbitrator will be an expert in the field of the dispute and his judgement will be made by opinion based on evidence presented.

Arbitrators can be appointed as the result of an arbitration agreement already in existence between the parties, by statute or by order of the court. Arbitrators can be appointed through a number of official and professional bodies.

### Alternative Dispute Resolution

The traditional methods of resolving disputes ( litigation and arbitration) are adversarial in nature involving the parties engaging each other in a contest before an independent tribunal. The contest does not necessarily involve a search for truth, it merely involves each side revealing enough of the truth to establish their case.

Press ENTER to go to next screen



## CONTRACT MANAGEMENT

You may now start the Intermediate knowledge section evaluation test

Press ENTER to go to next screen





CONTRACT MANAGEMENT (Intermediate Evaluation Section)

(Q3) The following are the most common types of Bonds used in engineering contracts.

- (i) Tender or Bid Bond.
- (ii) Performance Bond.
- (iii) Repayment Bond.
- (iv) Plant Performance Bond.

True

False

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer  
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-----  
The following are the most common types of Bonds used in engineering contracts.

- (i) Tender or Bid Bond.
- (ii) Performance Bond.
- (iii) Repayment Bond.
- (iv) Plant Performance Bond.

{True}

{False}

-----  
The correct answer is

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□ {True} □  
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Press ENTER to go to next screen

CONTRACT MANAGEMENT (Intermediate Evaluation Section)

(Q4) The contract price will be higher in many projects  
if the contractor was required to provide a Bond  
instead of a Retention.

True

False

Please choose an option

Please highlight your answer & Press ENTER to go to next screen

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The contract price will be higher in many projects  
if the contractor was required to provide a Bond  
instead of a Retention.

{True}

{False}

---

The correct answer is

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□ {True} □  
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Press ENTER to go to next screen



CONTRACT MANAGEMENT (Intermediate Evaluation Section)

- (Q6) The amount of Liquidated Damages compensation, can not be specified in the Conditions of Contract due to market variations.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Press ENTER to go to next screen

CONTRACT MANAGEMENT (Intermediate Evaluation Section)

(Q7) Variations in contracts can only be issued by the :

- I. Client
- II. Contractor

a I

b II

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer  
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Variations in contracts can only be issued by the :

- I. Client
- II. Contractor

{a} I

{b} II

The correct answer is

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□ {a} □  
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Press ENTER to go to next screen





CONTRACT MANAGEMENT (Intermediate Evaluation Section)

(Q9) All claims are grouped under the following heading:

\* Contractual claim.

True

False

Please highlight your answer & Press ENTER to go to next screen

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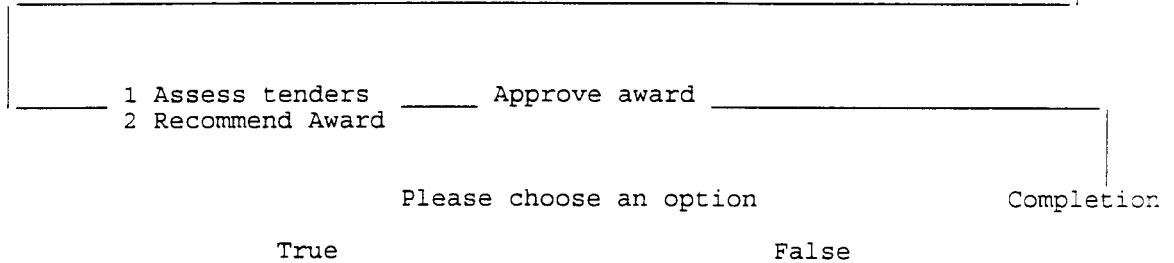
Press ENTER to go to next screen



CONTRACT MANAGEMENT (Intermediate Evaluation Section)

(Q11) The diagram below explains the steps of a tender process.

Establish need \_\_\_\_\_ 1 Requisition \_\_\_\_\_ Approve bid list \_\_\_\_\_  
for Contract 2 Pre-qualify  
3 Partner note

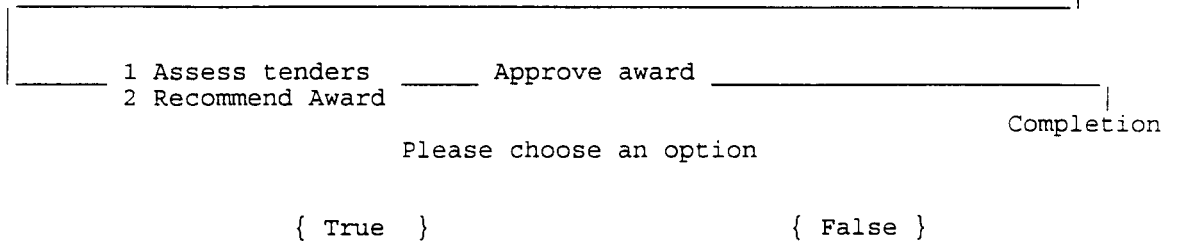


Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer  
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The diagram below explains the steps of a tender process.

Establish need \_\_\_\_\_ 1 Requisition \_\_\_\_\_ A pprove bid list -----  
for Contract 2 Pre-qual  
3 Partner note



The correct answer is { True }

Press ENTER to go to next screen











[illegible]

## Intermediate Section on CONTRACT MANAGEMENT

[illegible]

Press ENTER to go to next screen



Establishing the Contracting Plan

- a. This is the most important step in contracting because it lays the foundation for all succeeding phases. So the plan should be developed as early as possible to avoid having desirable contracting alternatives foreclosed unnecessarily.
- b. This involves analysis of the particular circumstances of the project, e.g. project size, schedule incentives, degree of definition possible at the time of inquiry, requirement for purchased technology.
- c. The contracting plan will delineate the preferred contract type and number of contractors for optimum results, with alternative retreat positions if the preferred route can not be achieved.
- d. A major input of the Project Manager is in determining the incentives for early completion and developing the degree of commitment at possible cancellation points.

Press ENTER to go to next screen

Completion Of the Contract and Work

Failure to complete does not release the client from the contract but he may be able to claim damages for any delay in completion. The client can also give notice to the contractor to complete by a specified date. Where there is substantial compliance the contractor is entitled to the contract sum less the value of omissions or the cost of rectification. The contractor must carry out all work necessary whether in drawings or specifications or not before he can claim completion.

Press ENTER to go to next screen

Developing Screening and Bidding Slates

- a- Screening advises the contractors about the project and solicits their interest in and capabilities for executing the work on the Owner's desired basis.
- b- In soliciting proposals for a project, a formal invitation is always used, even when a contract is negotiated without competition.
- d- During this phase, the Project Manager must also agree to any changes in contracting strategy which may be indicated by response of prospective bidders.
- e- Since the Project Manager has ultimate responsibility for successful execution of the project, he must assess the current capabilities of the bidders.

Press ENTER to go to next screen

TENDERING PROCEDURE

Several different procedures are available for selecting contractors:

- \* Open or select competition - the latter implying a restricted number of bidders.
- \* Two stage - a contractor is selected competitively, but early in the design process. As design and planning proceeds the final tender is developed from cost and price data supplied with the initial tender.
- \* Negotiated - usually with a single contractor but may be up to three contractors.
- \* Continuity - contractors tendering competitively are informed that the appointed contractor may be awarded continuation contracts for similar projects based on his original tender.

Press ENTER to go to next screen

Reviewing Bids

- a Bid Review procedures vary considerably between lump sum (LS) and reimbursable cost (RC) contracts. The latter have much more room for subjectivity and bias.
- b During the bidding and review period the Project Manager must respond promptly to all requests from the bidders for clarification and see that all bidders receive the same additional information or advantage in the competition.
- c On LS projects there is separate commercial and technical execution evaluations, On RC projects the concern is with the commercial evaluation of the project.

Press ENTER to go to next screen

THE CONSTRUCTION MANAGEMENT CONTRACT

The construction management contractor carries similar responsibilities to the management contractor. The important difference is that construction contractors are responsible to the client. This produces the following differences from a management contractor:

- \* the construction management firm need not be a contractor,
- \* construction contracts can carry the normal risk required by the client,
- \* the construction management firm has no commercial or professional conflict of interest.

The construction management contract is similar to the conventional approach of separate design and construction except that the management responsibility is separately identified and likely to be more rigourously defined and executed.

Press ENTER to go to next screen

#### THE DESIGN AND MANAGEMENT CONTRACT

A version of management contracting where detailed design is the direct responsibility of the design and management contractor. As a result it has similarities with Design and Build in that:

- \* there is a single point of contact for the client,
- \* management of design and construction is integrated,
- \* specification must be defined early in the design phase,
- \* time is saved from the design/construction overlaps,
- \* the likelihood of better design buildability is enhanced,

Press ENTER to go to next screen

#### The Design and Management Contract

It differs from Design and Build in that payment is similar to the management contract, the client has greater control (e.g. over sub-contract content and sequence) and is less committed to the whole technical package, in addition:

- \* the client relationship with the Design and Management contractor is more professional and collaborative,
- \* the Design and Management contractor does not construct and carries less construction risk,
- \* change is easier and negotiation of prices for change more equitable.

Press ENTER to go to next screen

Further Client Responsibility

\* Contract administration

The administration and control of the the contract is the responsibility of the client.

\* Performance Measurement

During and at the end of the contract the client should be measuring the performance of the contractor. There will be many quantitative measures taken through the monitoring of actual progress against the plane or project schedule.

Press ENTER to go to next screen

(Completion of the contract and work)

Continuing Liabilities

A contractor has certain liabilities at law even after formal completion of a contract. These are under the following:

Sale of Goods Act 1979,  
Supply of Goods and Services Act 1986  
Latent Damage Act 1986  
The Tort of Negligence

as well as general liabilities under the contract including taxes, patent and proprietary rights and insurance liabilities.

Press ENTER to go to next screen

(Uncontrolled Changes to Contract)

Types of Claim

Claims can be grouped under the following headings:

\* Contractual claim

Where the matter is covered within the terms of the contract, but where the contractor and client cannot reach agreement. Normally due to differing interpretations of the terms of the contract.

\* Extra contractual claim

A claim of right which would be enforceable at law but is not covered within the contract e.g. where client breaches contract, where no provision is made in the contract, misrepresentation etc.

\* Ex gratia claim

A claim having no legal foundation but which warrants consideration on hardship grounds, or on moral grounds.

When an ex gratia payment is made it does not assume liability by the client.

Press ENTER to go to next screen

Dispute Resolution

Arbitration

This is the process of settlement of any dispute by an arbitrator, who is somebody appointed to settle a dispute of any type. A key factor being that the arbitrator will be an expert in the field of the dispute and his judgement will be made by opinion based on evidence presented.

Arbitrators can be appointed as the result of an arbitration agreement already in existence between the parties, by statute or by order of the court. Arbitrators can be appointed through a number of official and professional bodies.

Mediation/conciliation

Mediation is a non-binding, without prejudice process in which both parties are brought together with an independent third party known as a mediator or neutral. The mediator must be acceptable to both parties.

Press ENTER to go to next screen



## CONTRACT MANAGEMENT

You may now start the Advanced knowledge section evaluation test

Press ENTER to go to next screen





















CONTRACT MANAGEMENT (Advanced Evaluation Section)

(Q10) The construction management contractor carries similar responsibilities to the management contractor.

The important difference is that :

- a Construction contractors are placed directly with the main contractor.
- b Construction contractors are placed directly with the client.
- c Construction contractors are placed directly with the project manager.

Please highlight your answer & Press ENTER to go to next screen

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Press ENTER to go to next screen



CONTRACT MANAGEMENT (Advanced Evaluation Section)

(Q12) Project management objectives are a combination of :

- I. The objectives for performance of the completed scheme.
- II. Achieving this performance within a specified cost or budgetary limit an
- III. Getting the project into use by a target date.

- |              |           |
|--------------|-----------|
| a I, II      | b II, III |
| c I, II, III | d I, III  |

Please highlight your answer & Press ENTER to go to next screen

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Project management objectives are a combination of :

- I. The objectives for performance of the completed scheme.
- II. Achieving this performance within a specified cost or budgetary limit an
- III. Getting the project into use by a target date.

- |                |             |
|----------------|-------------|
| {a} I, II      | {b} II, III |
| {c} I, II, III | {d} I, III  |

-----  
The correct answer is      àääääääääääääf  
                                 □ {c} □  
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Press ENTER to go to next screen













## **Appendix B**

Evaluation questionnaire of the contract  
management expert system

## The Use of Expert Systems in Training

Expert systems are used widely in the construction industry but not **as** yet within training. Therefore research is being undertaken at Edinburgh University to assess the effectiveness of an expert system within training. The system is an additional resource and is not intended to replace a lecture or a lecturer.

- **This exercise** within the Project Management course is intended :-
  - a- **to improve** your knowledge of Contract Management with the aid of the expert system;
  - b- **to contribute** towards evaluating the expert system.
- **Within the 40 minutes** allocated to each student, you should be able to:
  - a- **read** the first page of this hand-out which provides a background and gives instructions to the exercise;
  - b- **proceed** through the expert system and make a note of the scores achieved on page 2;
  - c- **complete** an evaluation on pages 3,4 and 5.

*Please note that your answers are completely confidential*

## Expert System on Contract Management

This Expert System is a rule-based system, known **as** EXCONTR 1.2, and was developed using a shell (Crystal4.5). EXCONTR 1.2 contains **four sections**, the **general** section, **basic** section, **intermediate** section, and **advanced** section.

---

You **as** the trainee will **start at the general** section, where you will be taken through an evaluation to determine your present level of knowledge on Contract Management. The system would decide on the next section, and you would cover various levels up to the advanced section, **Please do not forget to note the score at the end of each level.** On completion of the expert system, please fill in the subsequent feed back questionnaire.

**You will be able to access EXCONTR 1.2 by :-**  
**Highlighting "MS DOS CRYSTAL" icon on project management group 1996.**



## **Section 2: Contract Management Evaluation Tests.**

**As** you go through the four sections, i.e. general, basic, intermediate and advanced, **of** the Contract Management expert system, you will be given your scores at the end of each evaluation test.

Please enter them below.

- |   |                |
|---|----------------|
| <b>(a) General section final score</b>      | <b>(.....)</b> |
| <b>(b) Basic section final score</b>        | <b>(.....)</b> |
| <b>(c) Intermediate section final score</b> | <b>(.....)</b> |
| <b>(d) Advanced section final score</b>     | <b>(.....)</b> |



## Section 3 : Feed back Questionnaire

The feed back questionnaire is the final section and is to provide feed back on the expert system.

Given below are a series of statements to which you **circle the number** corresponding to your view. They are graded **as** follows:

- 1** Strongly agree with statement
- 2** Slightly agree with statement
- 3** Have no opinion either way
- 4** Slightly disagree with statement
- 5** Strongly disagree with statement

	strongly agree			strongly disagree
1. Titles and screen formats are easy to follow.	1	2	3	4 5
2. Information is well presented within the knowledge base.	1	2	3	4 5
3. Keyboard instruction are clear.	1	2	3	4 5
4. System sections (general, basic, intermediate, advanced) have covered most parts of the topic.	1	2	3	4 5
5. Using expert systems in training can improve work effectiveness	1	2	3	4 5
6. Knowledge display forms gives a clear understanding to the subjects.	1	2	3	4 5
7. Expert system evaluation tests were well structured.	1	2	3	4 5
8. I would rather use an expert system for training than a lecturer.	1	2	3	4 5
9. Training expert systems are so complicated I would rather do my work conventionally.	1	2	3	4 5
10. I think that expert systems for training should be used <b>as</b> a supporting tool during training courses.	1	2	3	4 5
11. More knowledge is required on Contract Management in order to cover the four evaluation tests	1	2	3	4 5

12. An expert system tool in other topics of project management will lead to a better understanding to the subject	1	2	3	4	5
13. I feel that expert system for training is a beneficial tool in both education and industrial settings.	1	2	3	4	5
14. The expert system for training has improved the quality of my knowledge in Contract Management.	1	2	3	4	5
15. I find the evaluation questions within the expert system are easy to understand.	1	2	3	4	5
16. The use of expert system in training can save a lot of time.	1	2	3	4	5
17. Knowledge of Contract Management was not required prior to using the expert system.	1	2	3	4	5
18. I feel that I have improved my knowledge by performing the evaluation training programme.	1	2	3	4	5
19. Doing some reading before using the expert system could help in a deeper understanding of the questions.	1	2	3	4	5
20. The timing of the training program was very good.	1	2	3	4	5
21. Key points in the display forms can be found easily.	1	2	3	4	5
22. Speed of navigation through the expert system was adequate.	1	2	3	4	5
23. Higher training efficiency can be achieved with such an expert system.	1	2	3	4	5
24. I feel more confident in all aspects of Contract Management after going through the expert system.	1	2	3	4	5
25. More display forms on Contract Management are required in the knowledge base.	1	2	3	4	5
26. If I used computers in training I could save time and work.	1	2	3	4	5
27. Expert systems are superior to human in processing information.	1	2	3	4	5
28. More effort is needed from both computer science and project management researchers to build more comprehensive expert systems.	1	2	3	4	5
29. I think the evaluation of trainees after going through a training programme is an important step in achieving higher standards.	1	2	3	4	5
30. Written information in Contract Management should be provided prior to trainee starting the test.	1	2	3	4	5

- |  |   |   |   |   |   |
|--|---|---|---|---|---|
| 31. Trainee performance can be easily followed through all sections of the evaluation tests. | 1 | 2 | 3 | 4 | 5 |
| 32. It is useful at an early stage to define performance levels in the evaluation .          | 1 | 2 | 3 | 4 | 5 |
| 33. Wording of questions and options are clear.  | 1 | 2 | 3 | 4 | 5 |
| 34. The expansion of new technologies is making working conditions better.                   | 1 | 2 | 3 | 4 | 5 |
| 35. I feel that computers are necessary tools in both education and work                     | 1 | 2 | 3 | 4 | 5 |
| 36. I had no earlier experience on the subject of Contract Management.                       | 1 | 2 | 3 | 4 | 5 |
| 37. I felt that the expert system was too difficult for me.                                  | 1 | 2 | 3 | 4 | 5 |
| 38. I think Contract Management is still not explored well in engineering areas.             | 1 | 2 | 3 | 4 | 5 |
| 39. It is important to learn from experts experience   | 1 | 2 | 3 | 4 | 5 |
| 40. I look forward to computers taking over certain routine tasks.                           | 1 | 2 | 3 | 4 | 5 |

---

**Please don't forget to return the questionnaire when you have completed it.**

**DO NOT PUT YOUR NAME ANYWHERE ON THIS QUESTIONNAIRE, AS IT IS NOT NECESSARY.**

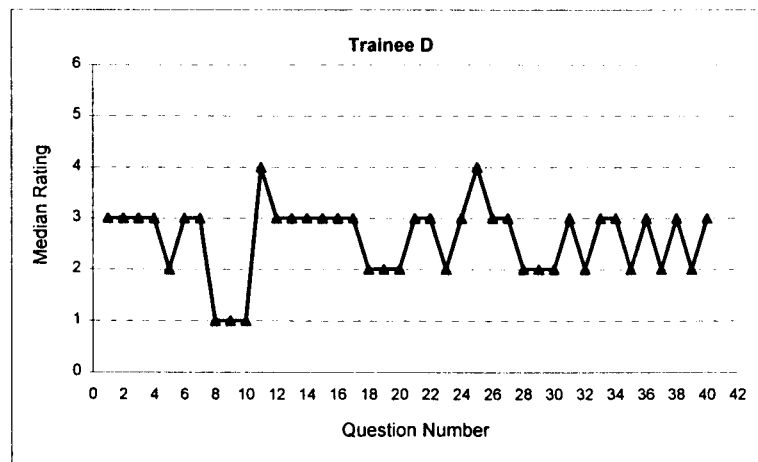
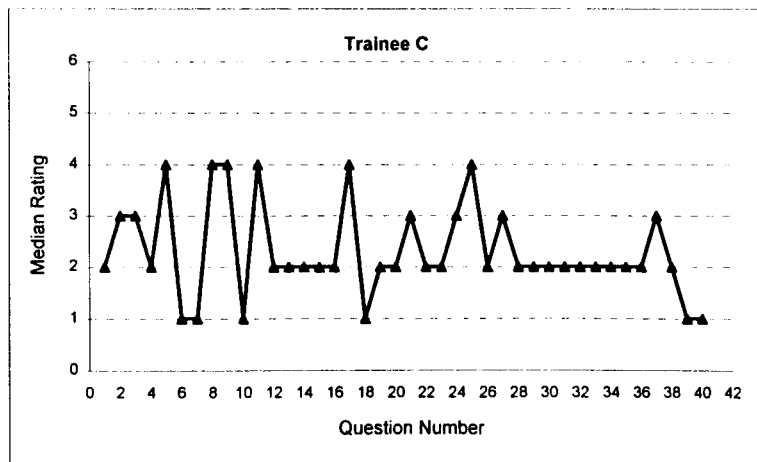
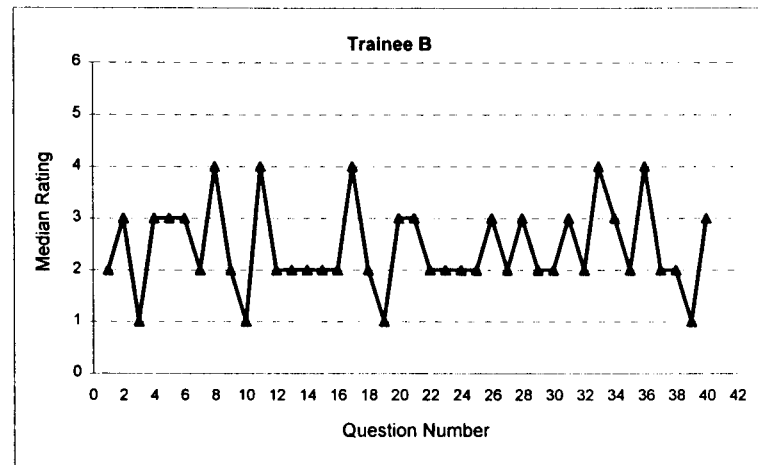
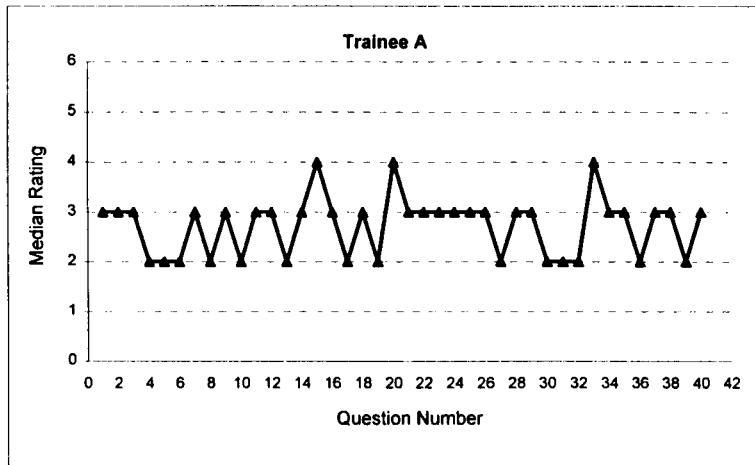
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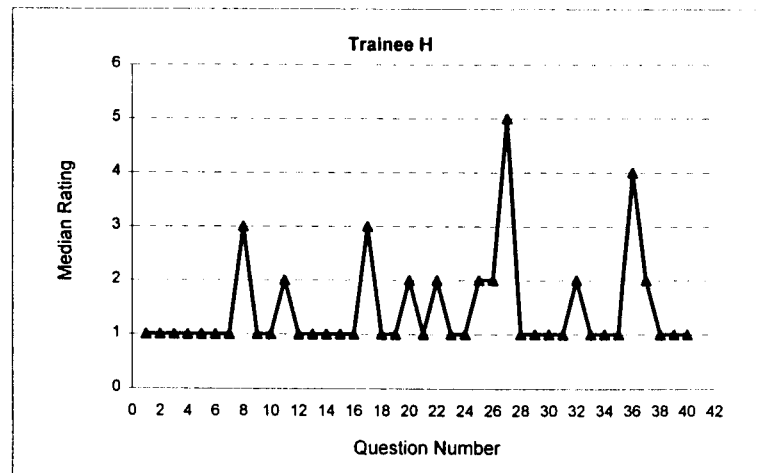
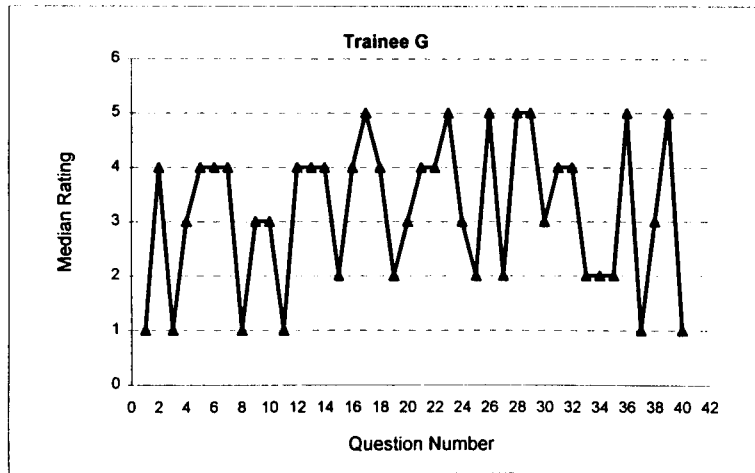
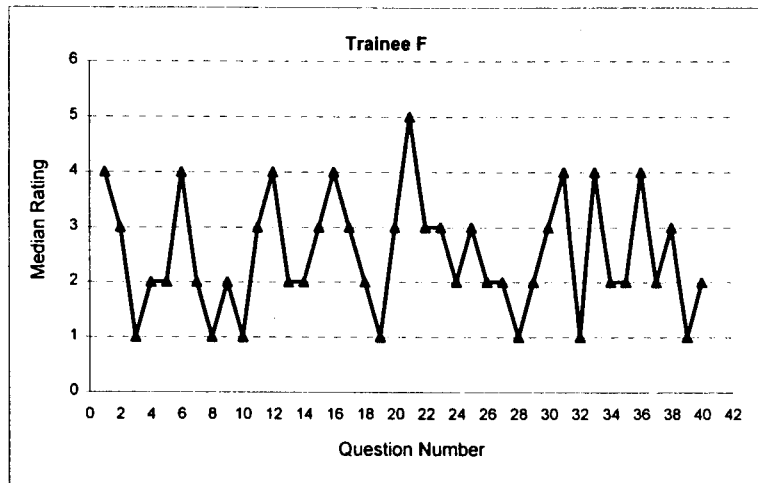
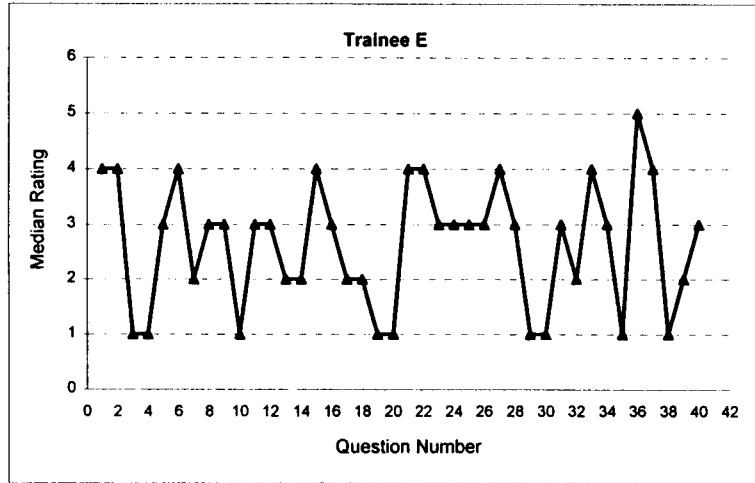


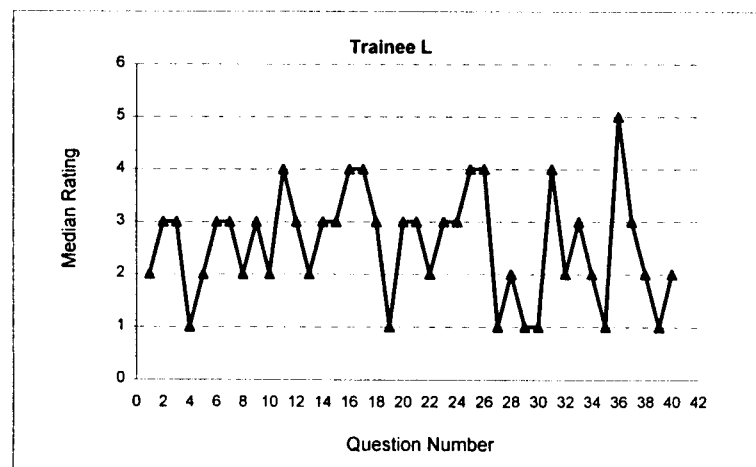
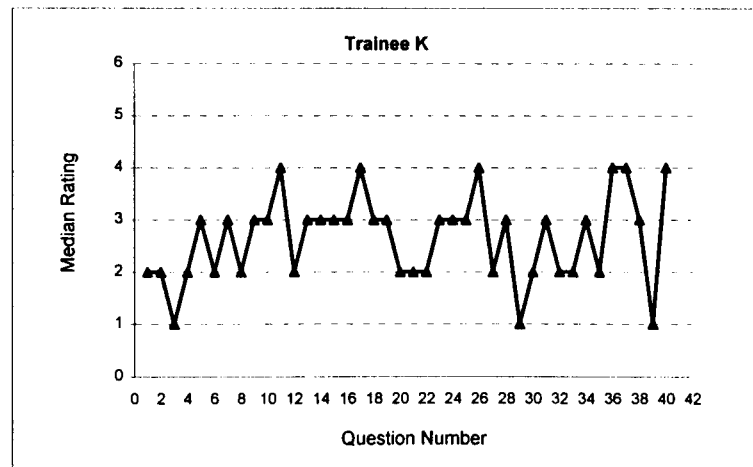
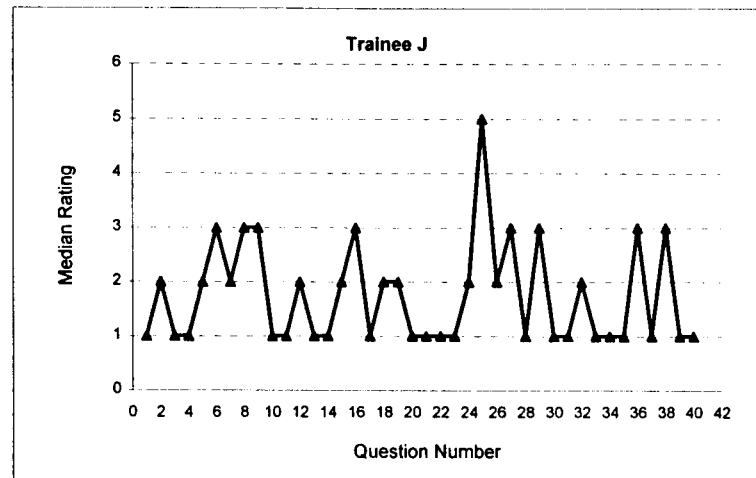
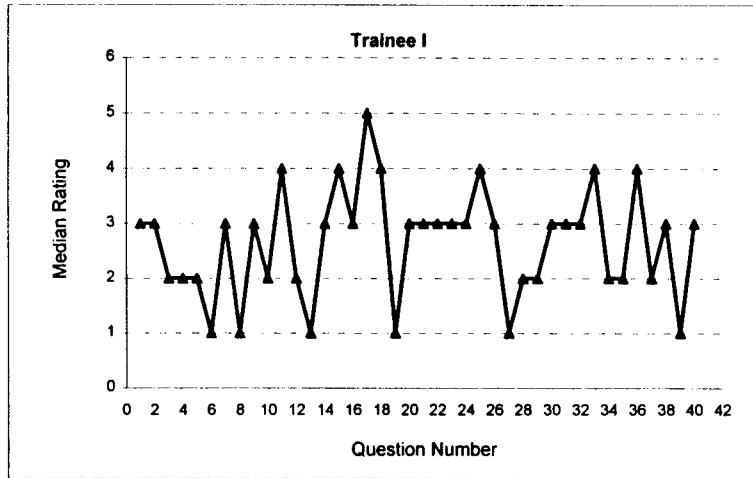
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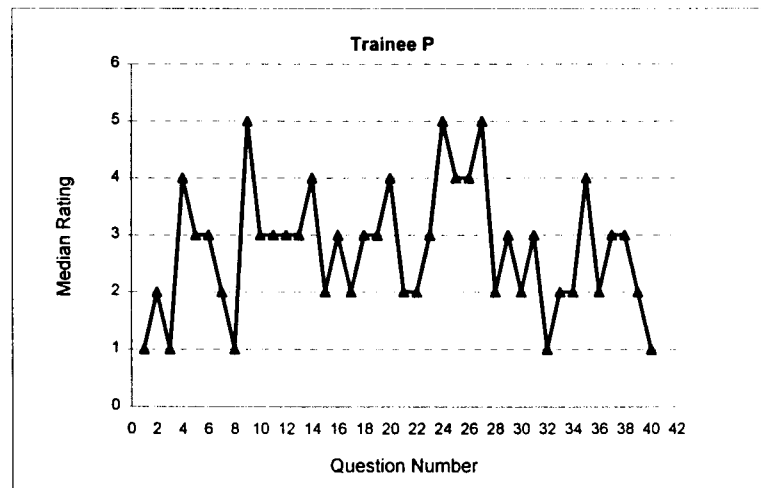
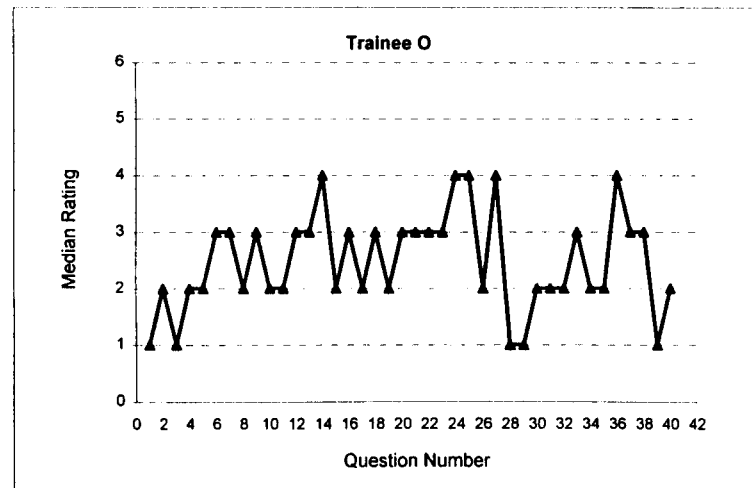
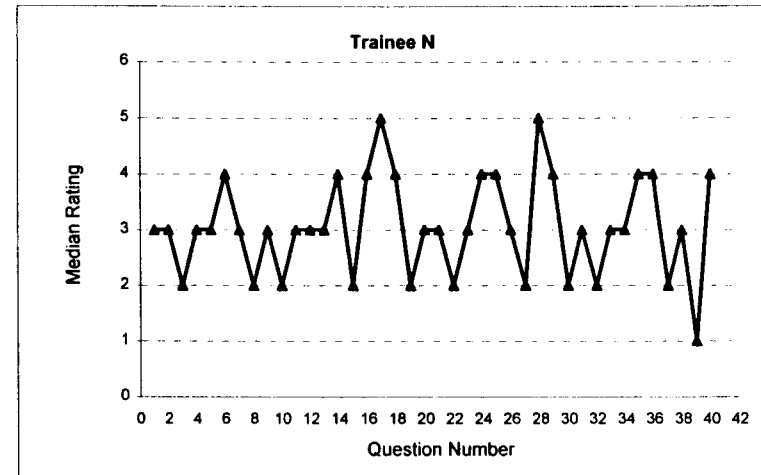
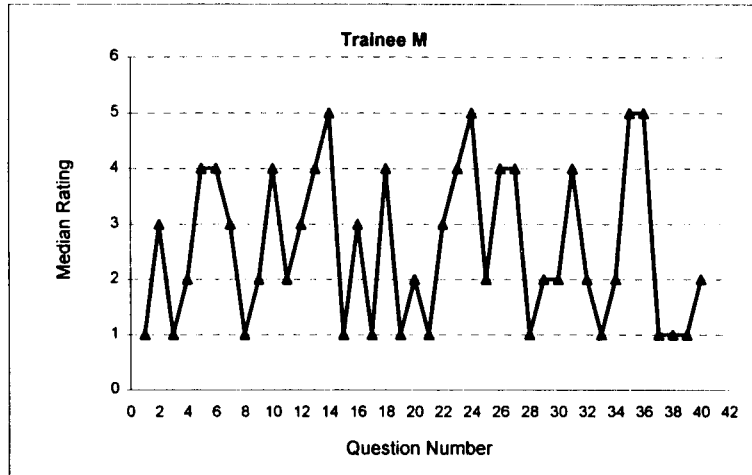
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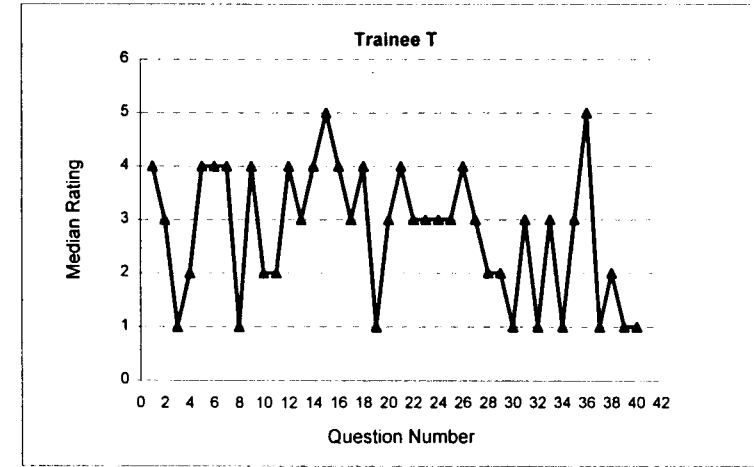
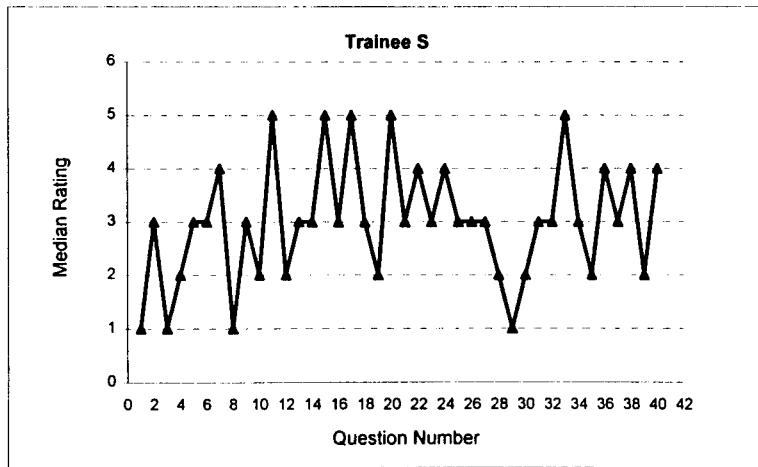
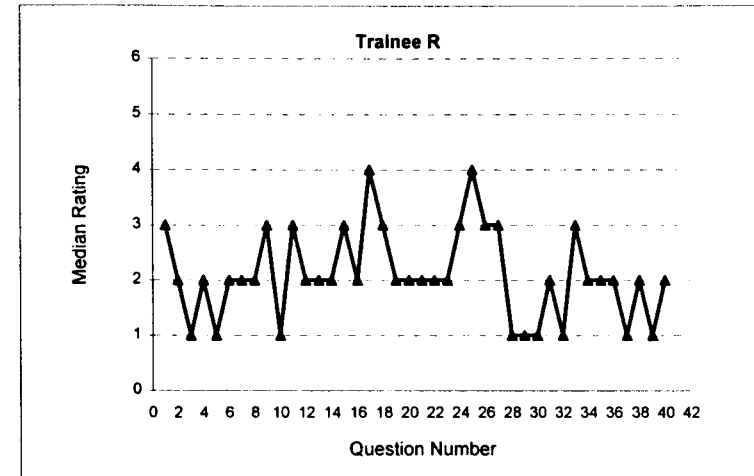
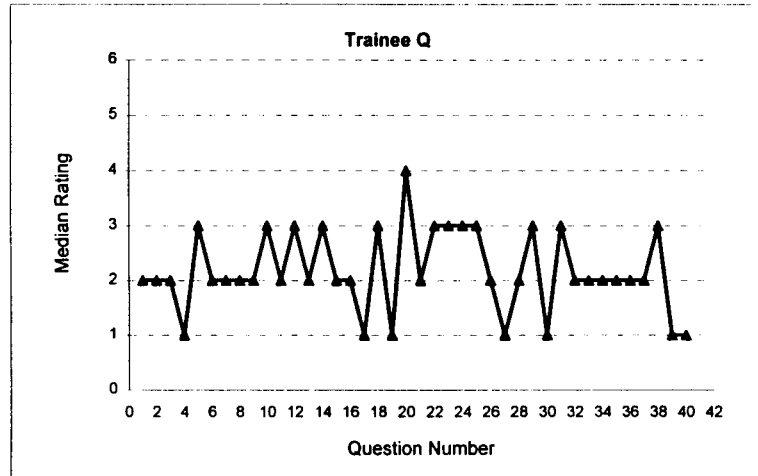
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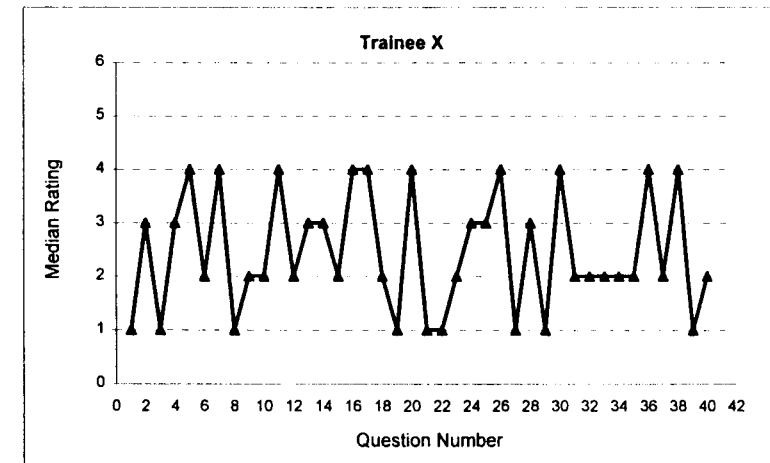
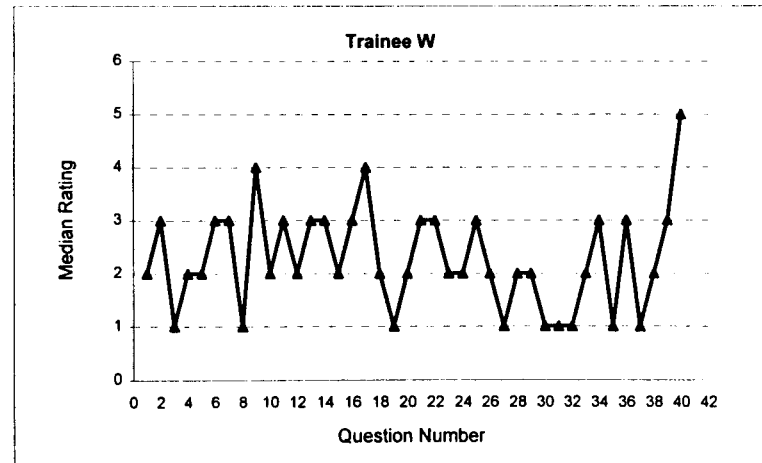
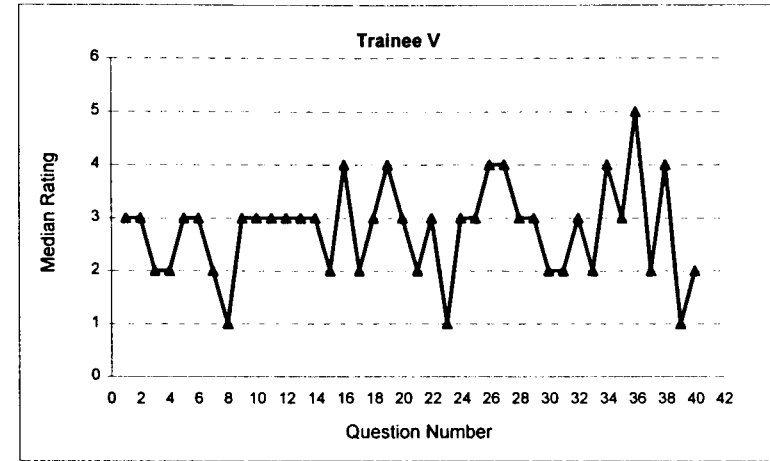
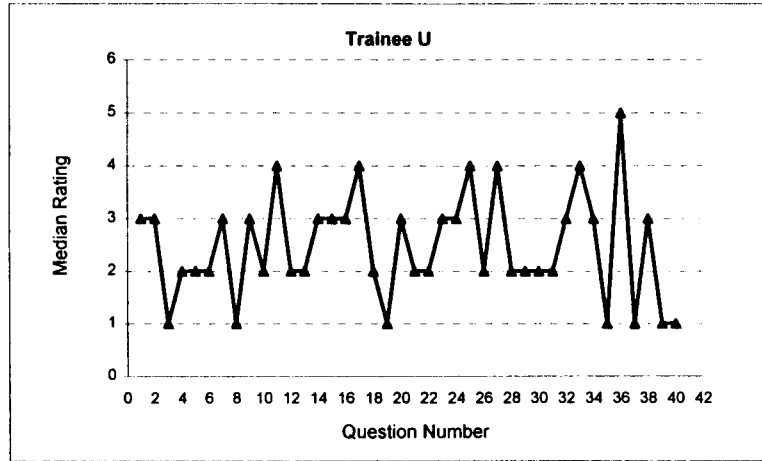


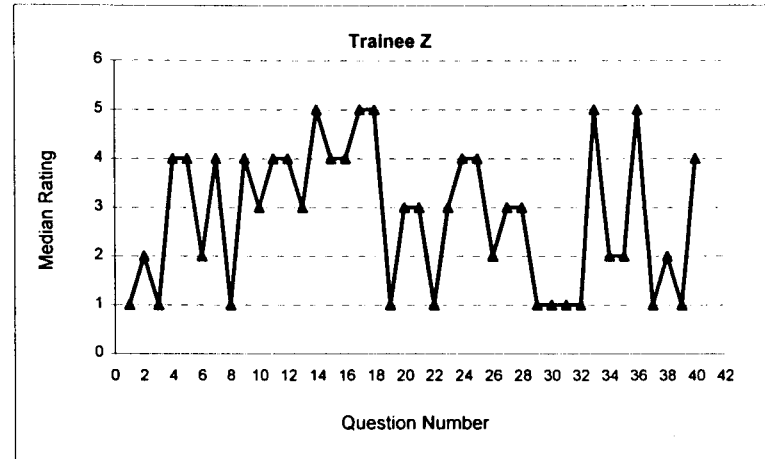
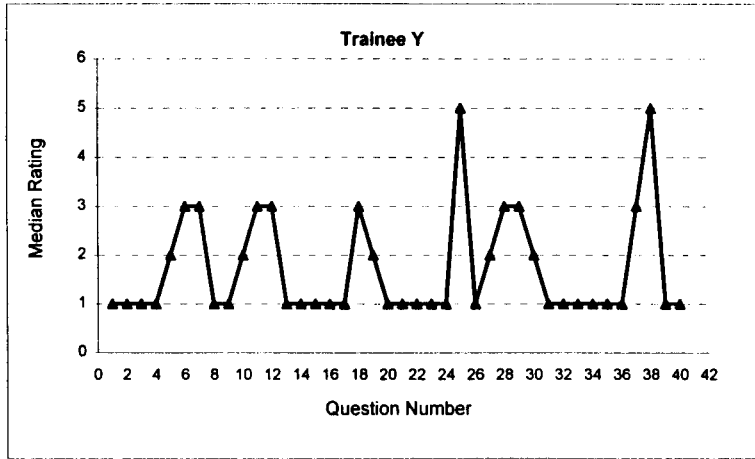






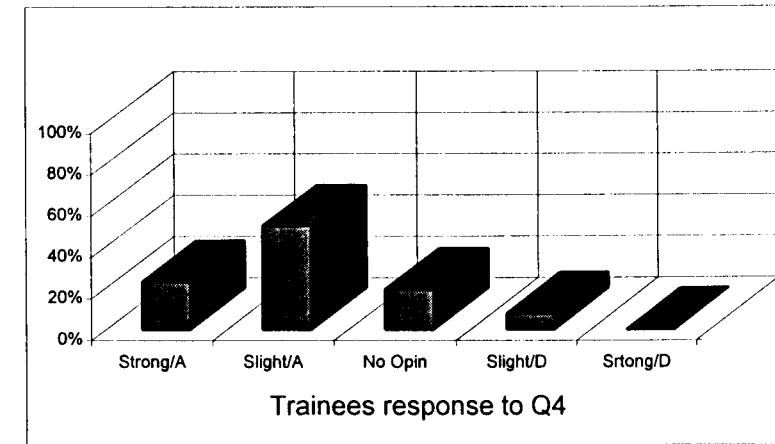
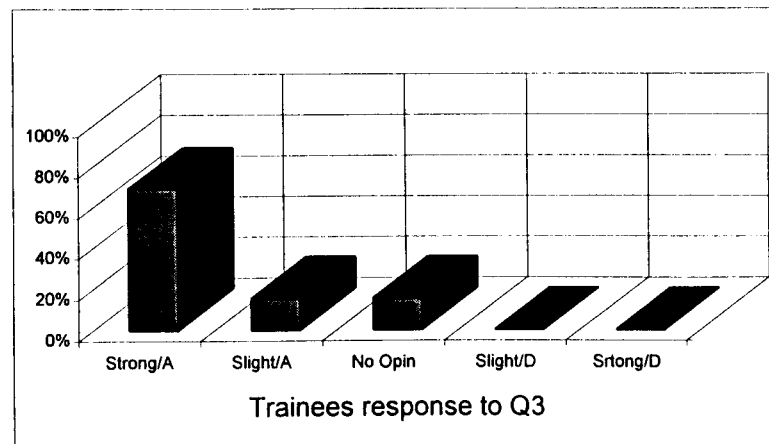
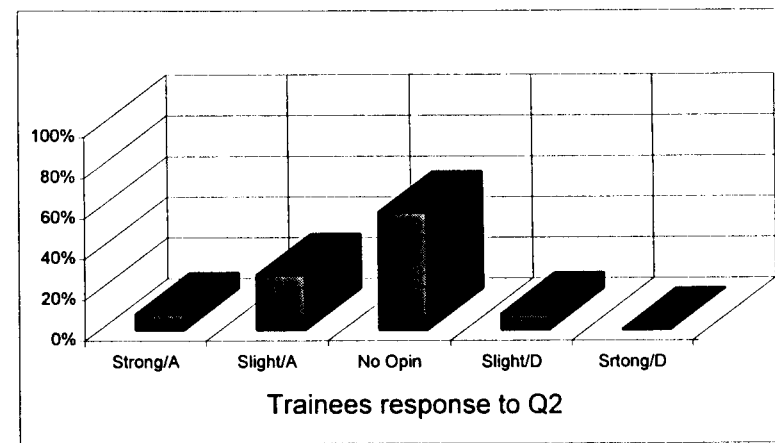
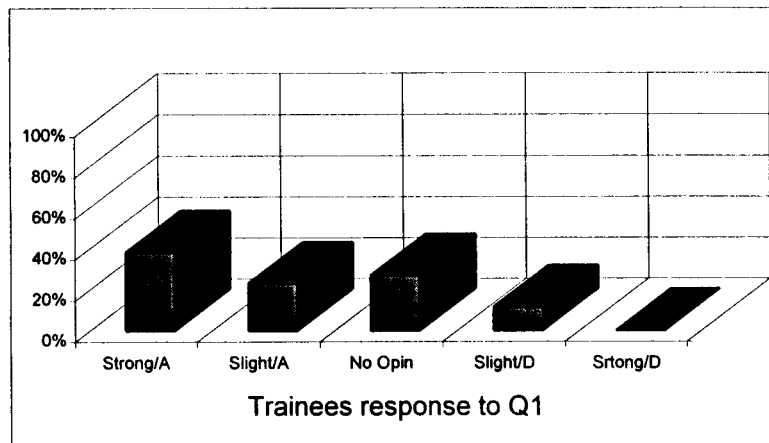


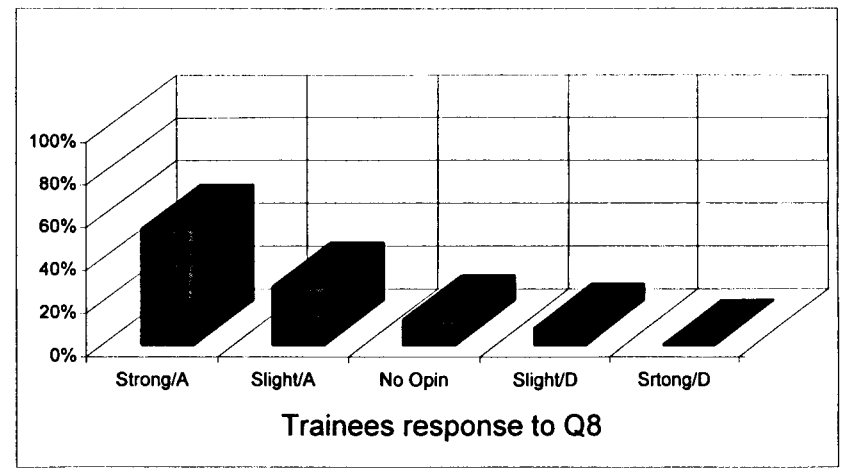
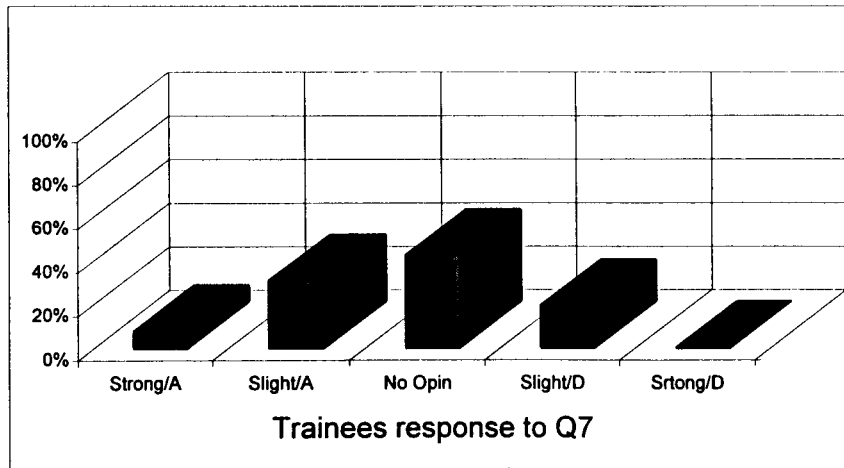
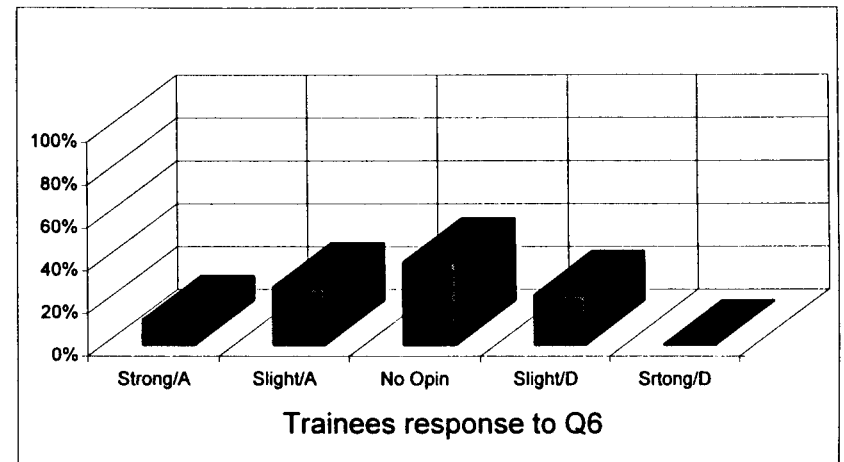
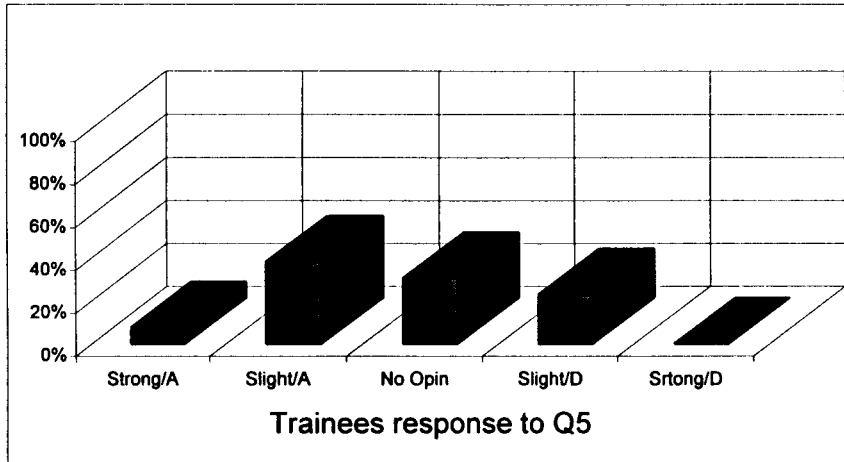


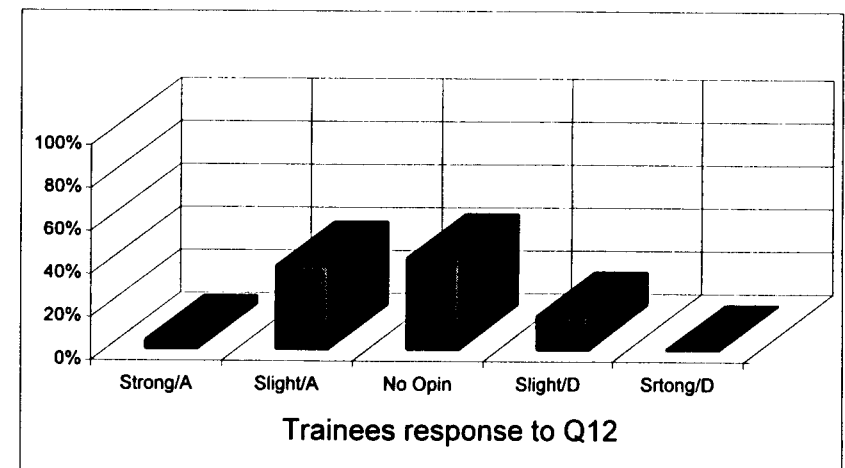
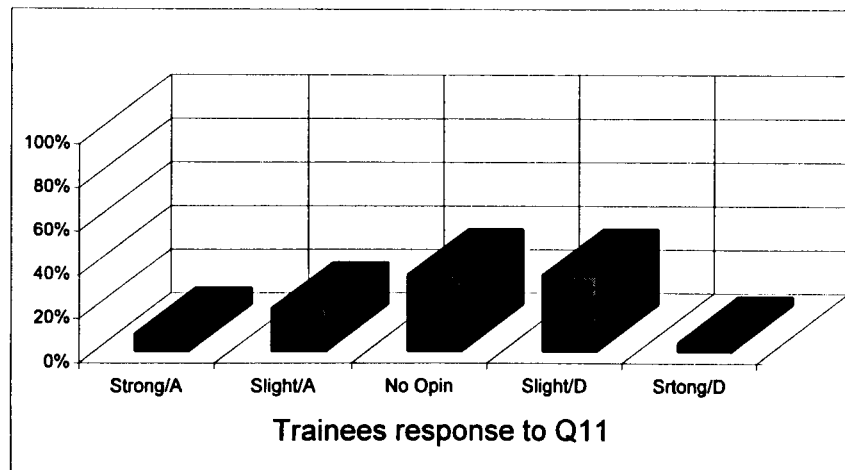
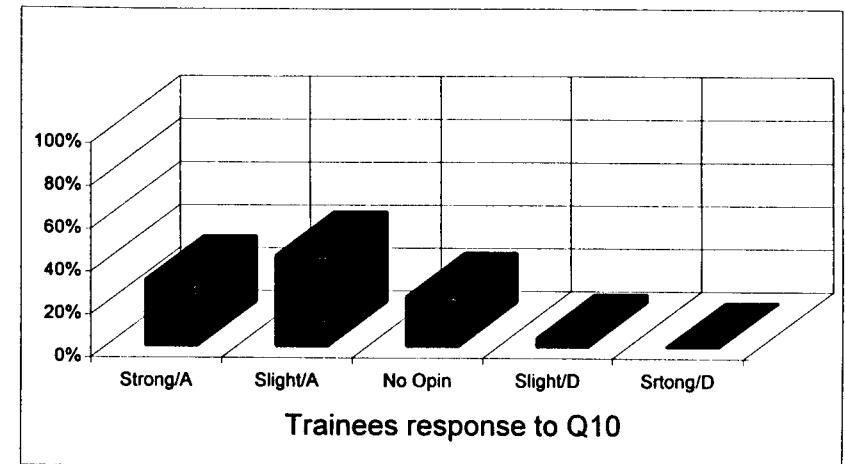
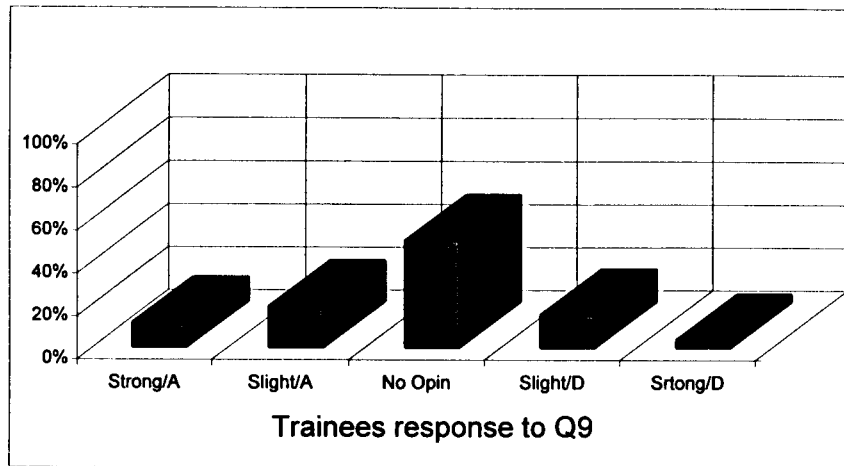


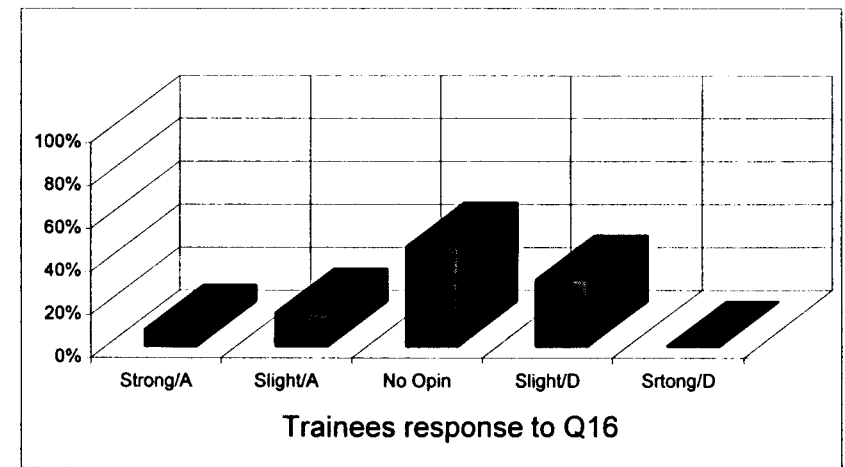
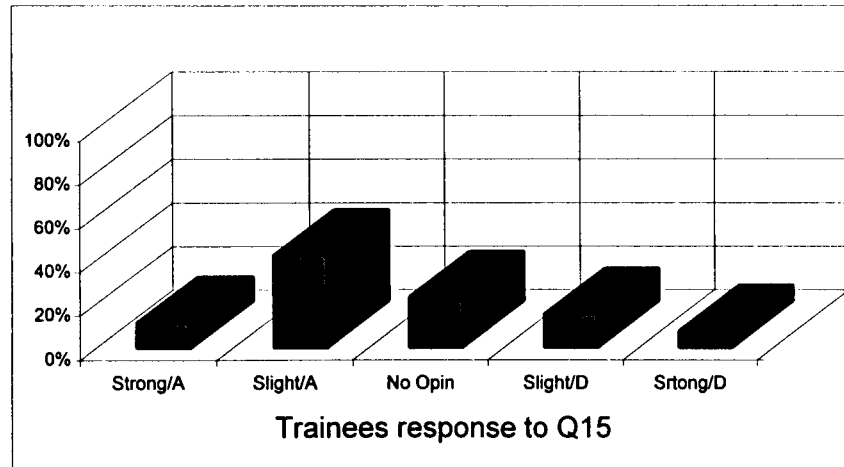
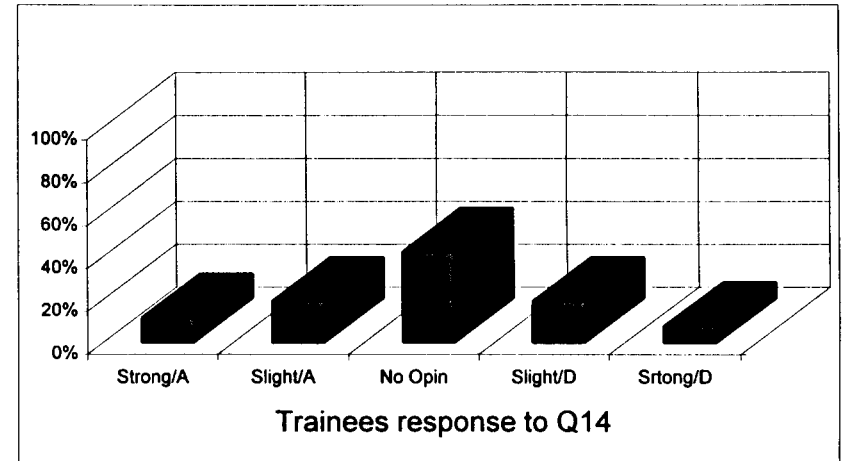
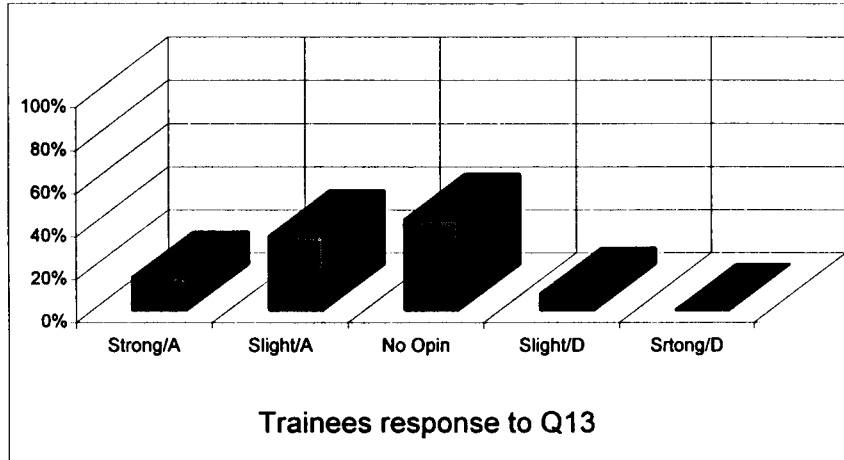


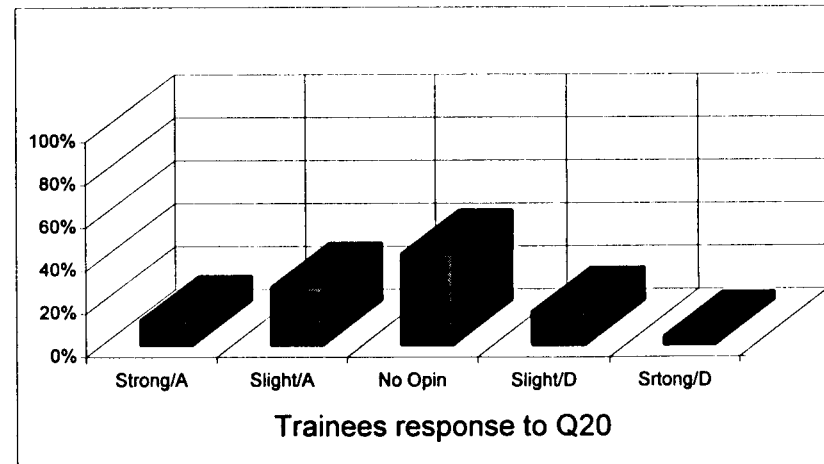
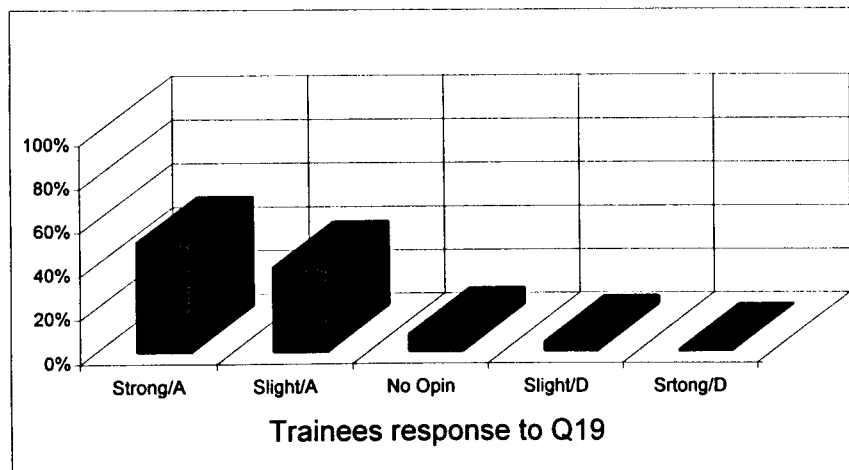
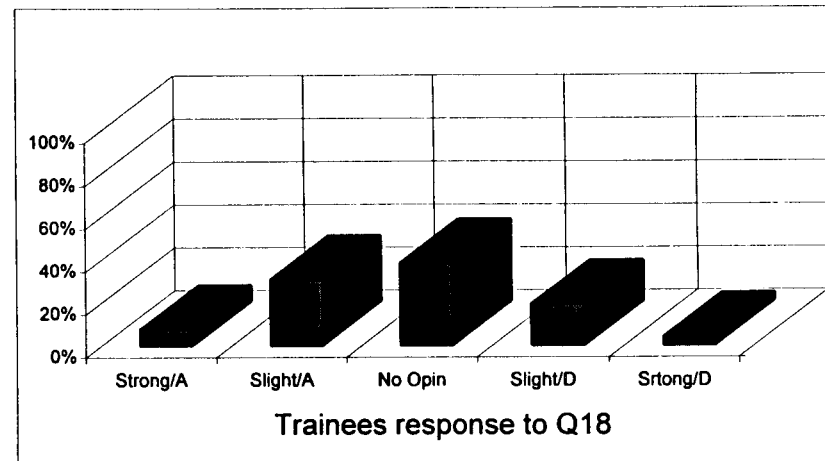
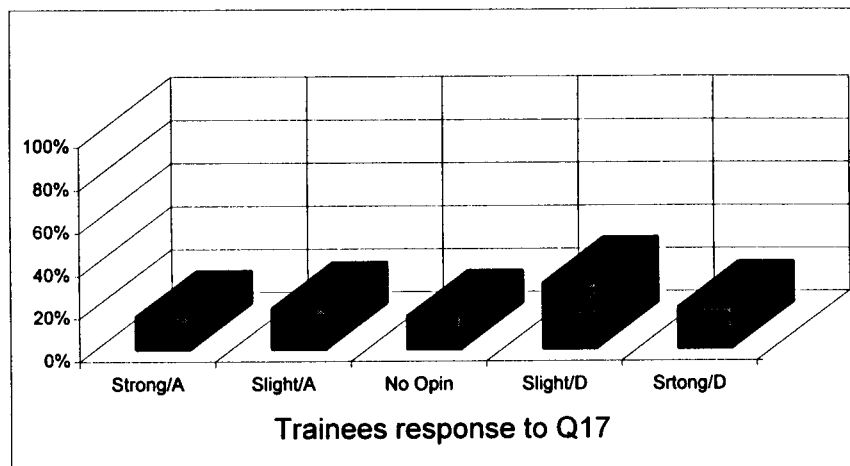
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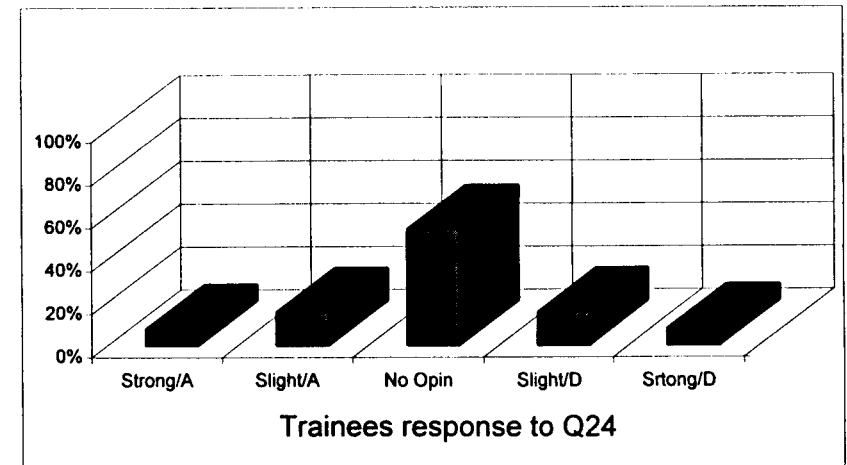
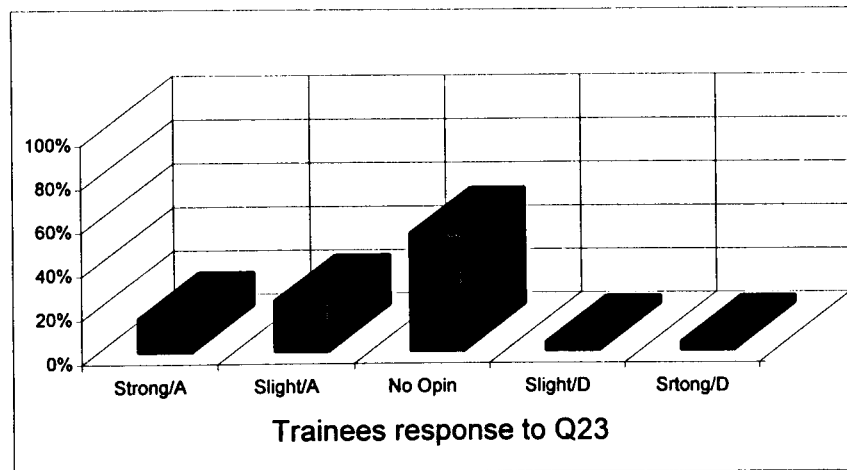
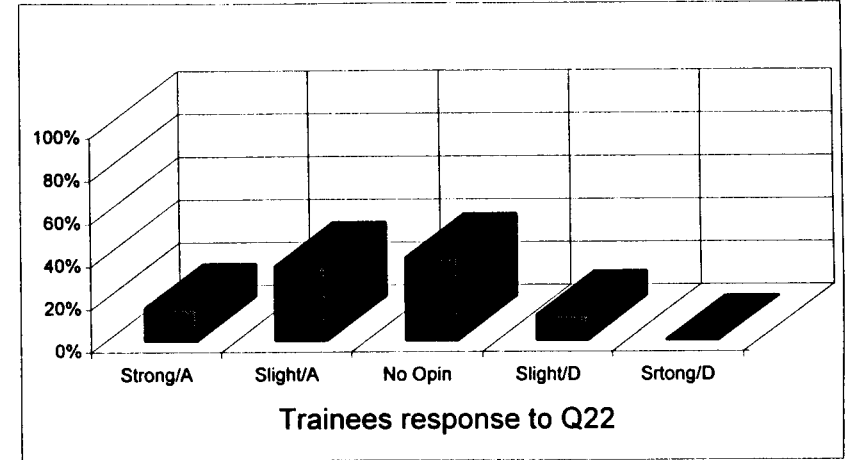
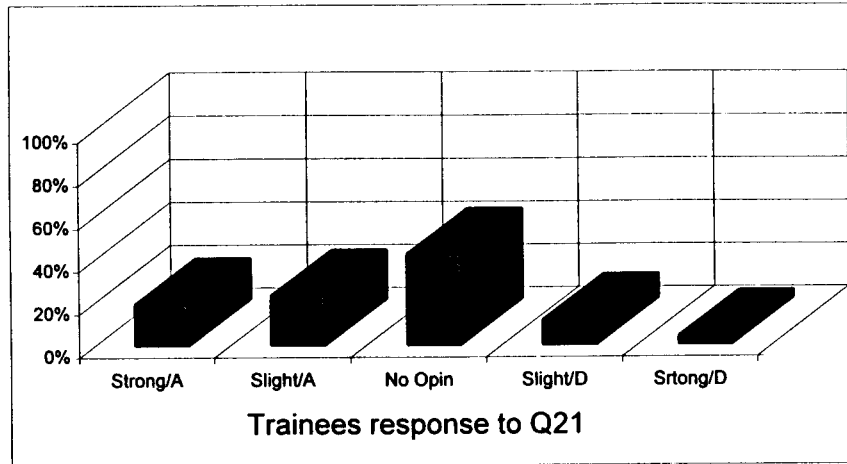


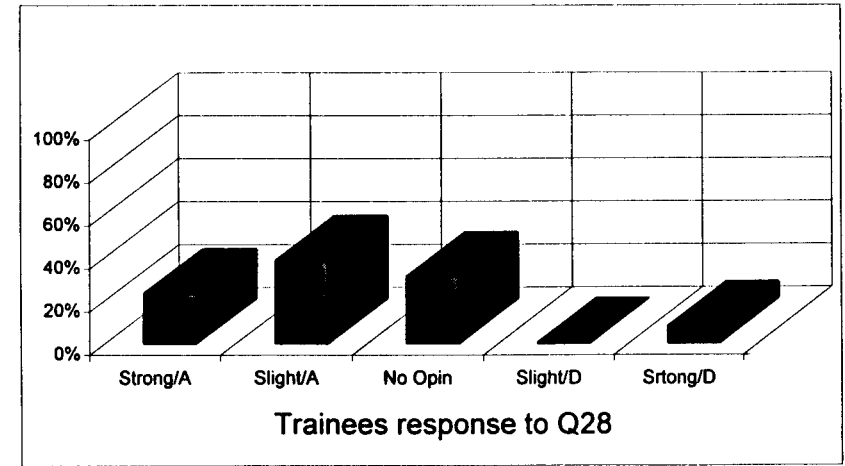
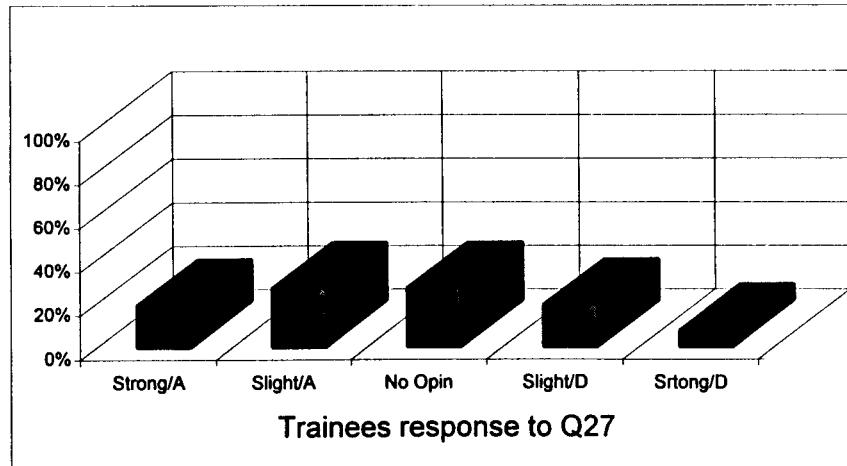
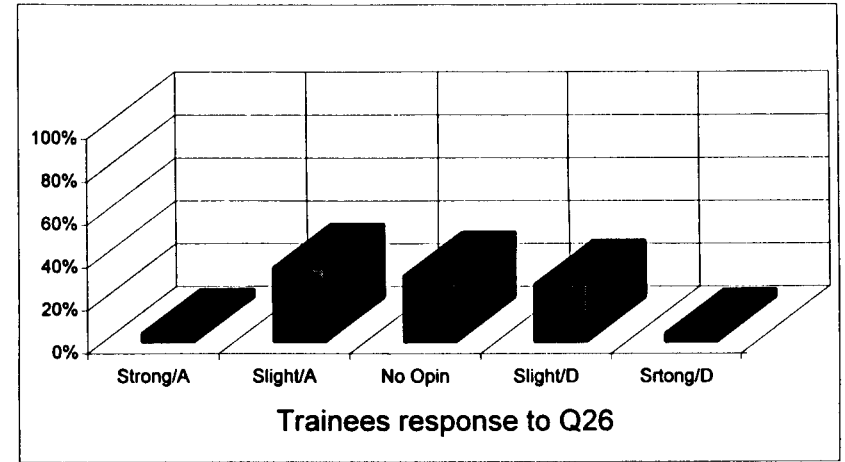
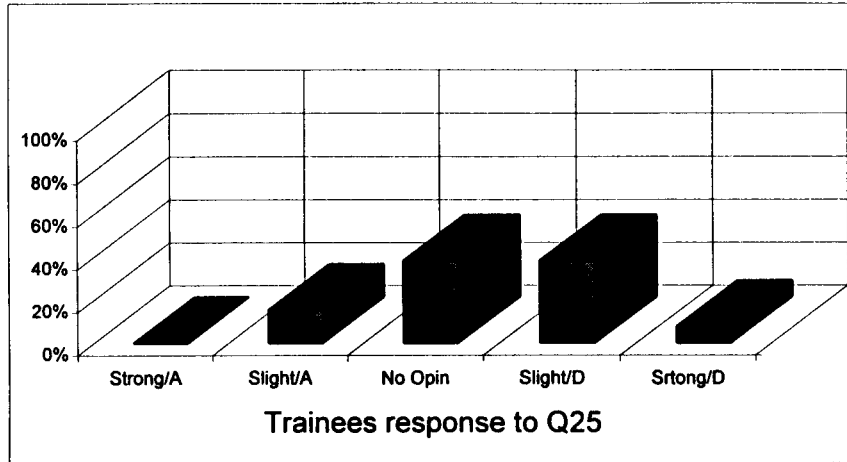


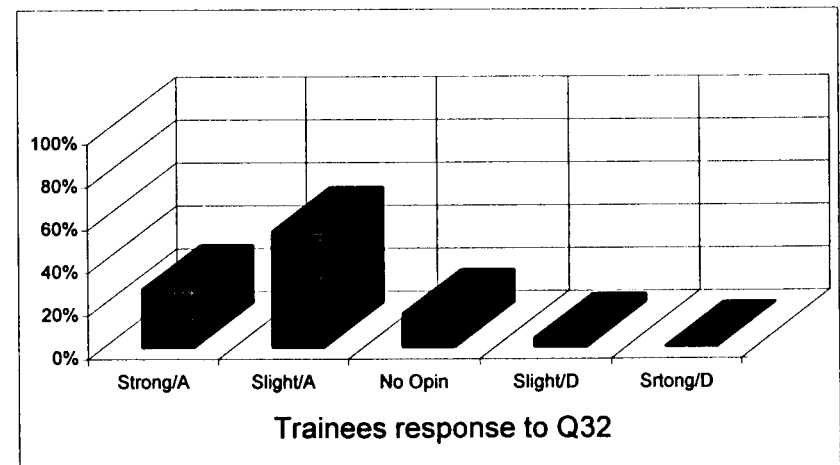
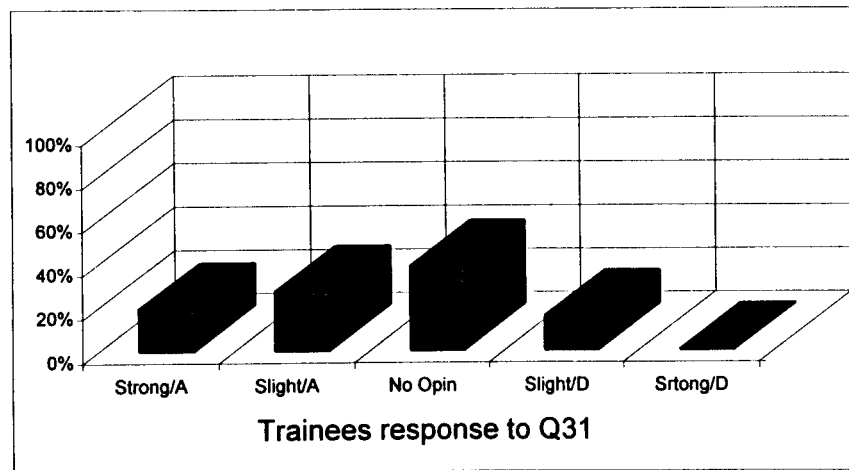
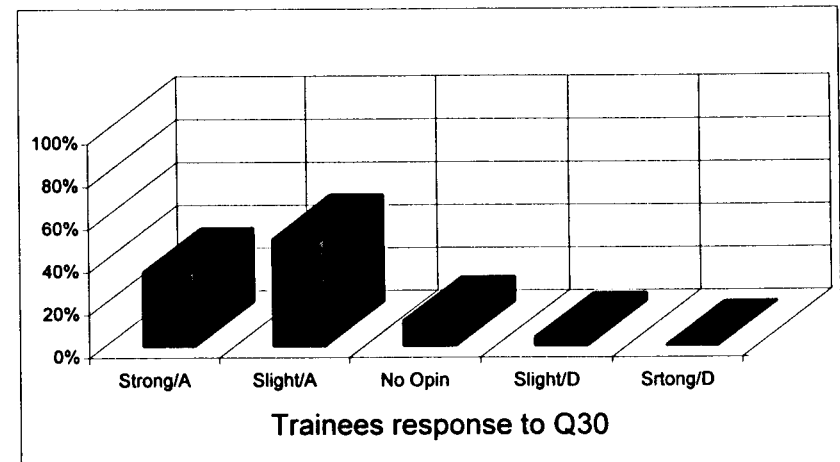
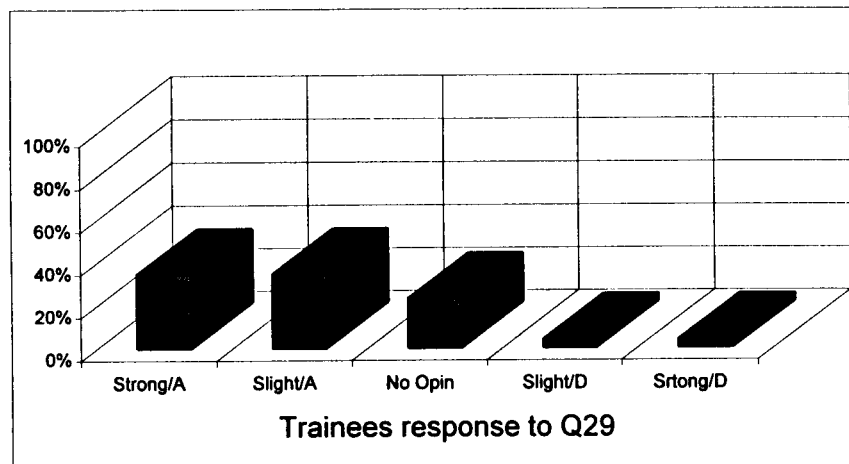




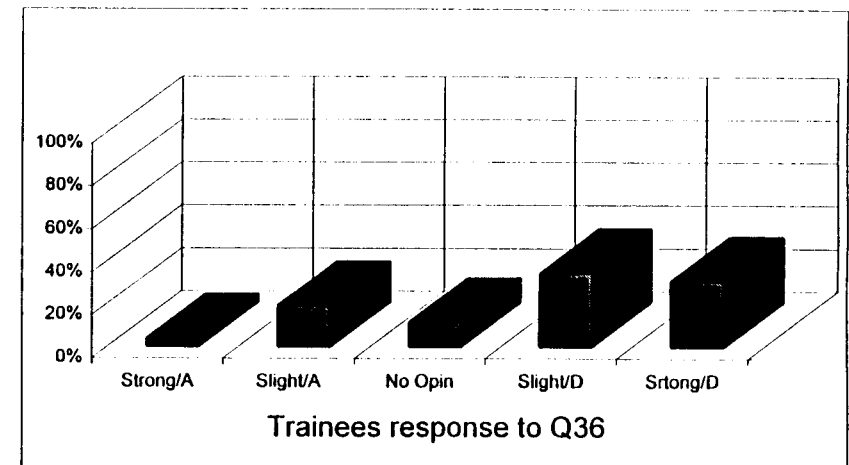
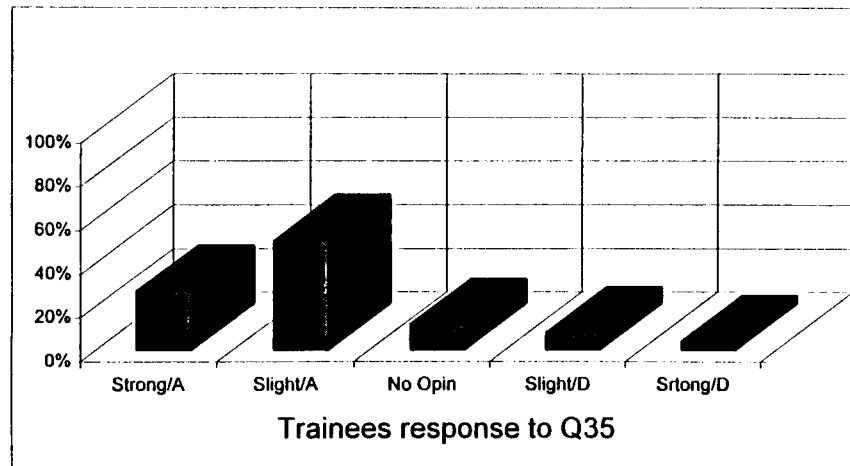
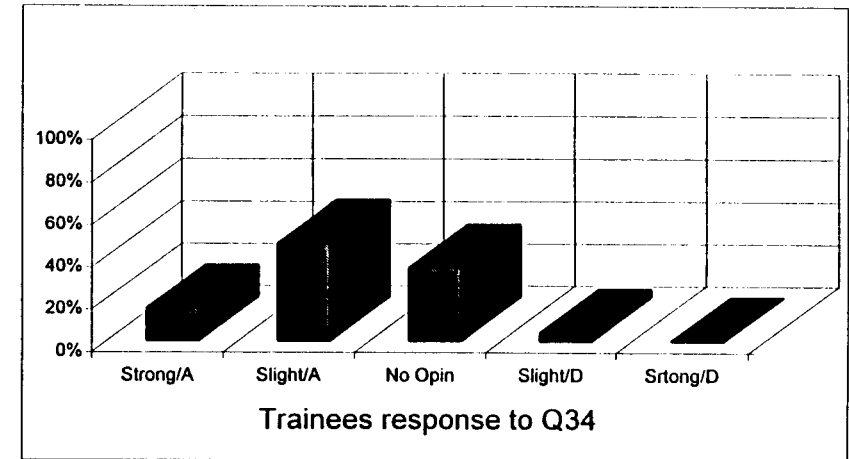
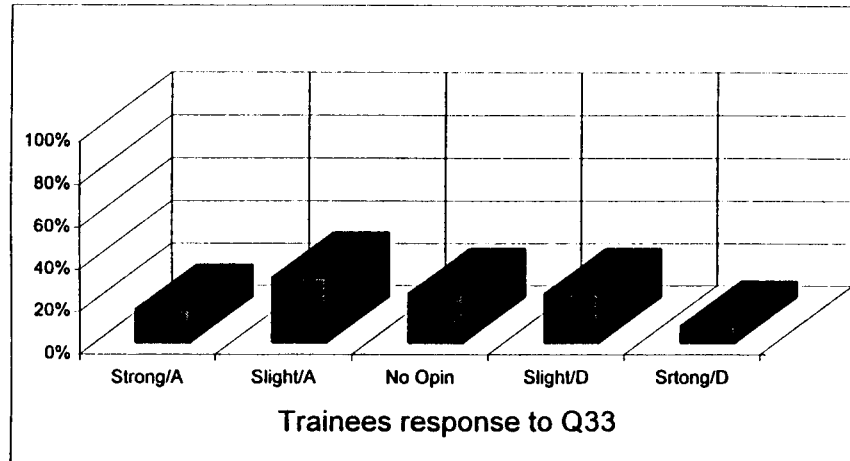


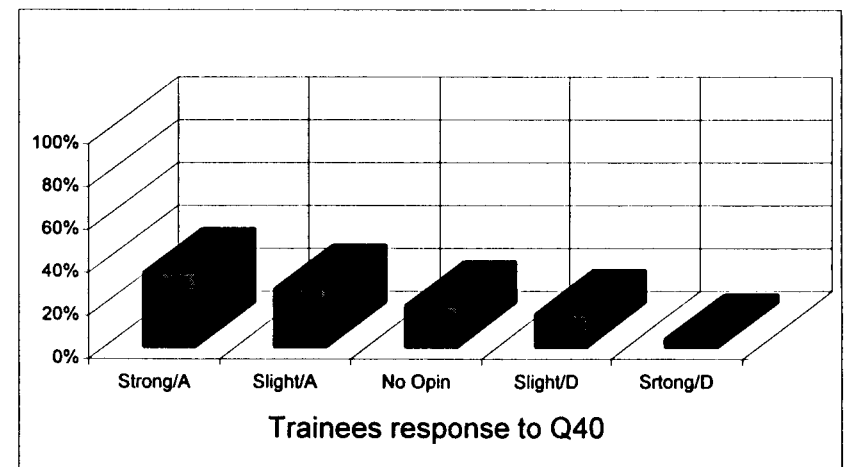
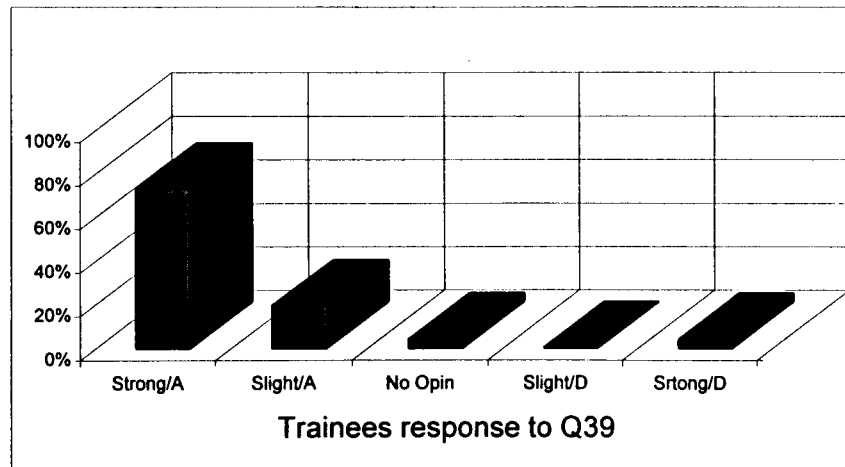
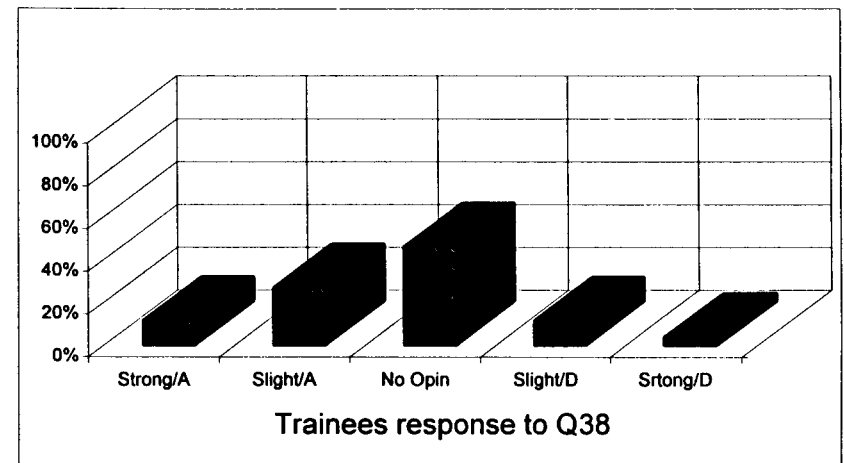
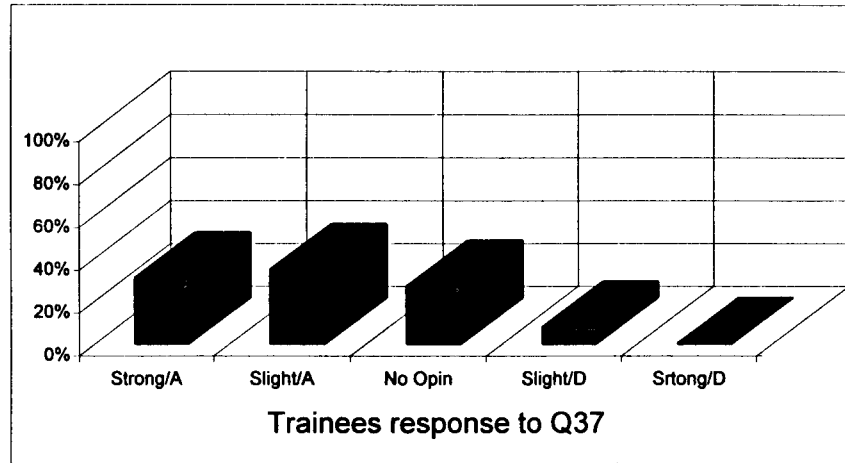












#### Organisation of Roles

For contracts providing services the main choices are:

- \* An external project management role or project management directly by the client or project management tasks allied to other duties (usually design);
- \* The contractor only constructs (fabricates and installs). i.e. separate design, usually by a consultant, as occurs in traditional civil engineering and building contracts;
- \* Contractor constructs with input to design (but no responsibility for it). This can be achieved by reimbursable, and management contracts or fee contracting;

Press ENTER to go to next screen

#### Organisation of Roles (Cont.)

- \* A proportion of design combined with construction by the contractor, so the boundary between scope design and detailed design (or process design and engineering) must be decided. This can be achieved by design and build on a turnkey basis or Engineering, Procurement and Construction (EPC).
- \* management only with design and construction by separate firms. This be achieved by the management contract or the construction management contract;
- \* design and management by the contractor, with separate trades contractors. This can be achieved by the design and management contract.

Press ENTER to go to next screen

## **Appendix D**

**A** run of the safety management expert system



## EXSAFE 1.1

To select your choice of answers please follow the steps below :

[illegible]

Press ENTER to go to next screen

EXSAFE 1.1

[illegible]

Press ENTER to go to next screen

## SAFETY MANAGEMENT

The following general introduction section contains eight display forms, they are numbered as : 1-9 to 9-9.

° Please read through the following display information before °  
° starting the General section evaluation on Safety Management. °

Press ENTER to go to next screen

## General Section on Safety Management

2

## Definitions and Beliefs

Let us begin with definintions and then outline our Safety Management Beliefs.  
Accidents

An undesired event that results in harm to people or the environment, damage to property or loss of process.

## Incidents

An undesired event which under different circumstances could have resulted in harm to people or the environment, damage to property or loss process.

## Safety Management Beliefs

- (a) Safety Management is the managed control of accidental loss.
- (b) In a project environment, Safety must be managed; and thus it should have equal managerial status with the project's macro objectives of schedual, budget and quality.
- (c) Safe working practices and due consideration to environmental factors are vital to the overall efficiency and success of projects large and small.

Press Enter to Go to Next Screen

Let us look at accidents purely (but not only) as a loss. We can therefore postulate a "Loss Causation Model" and seek to minimise the loss. Accidents and Incident are seldom, if ever the result of a single event. If we focus management attention to the objective "minimise loss", we will doubtless reduce accident but we will also make cost improvement and so maximise profit. Thus, in a project, we maintain our budget performance position

Form of Accident :

- ( i ) Harm to people
  - \* Suffering
  - \* Disability
  - \* Hardship
  - \* Psychological problems
  - \* Replacement costs
- ( ii ) Damage to Property
  - \* Repairs
  - \* Replacement
  - \* Insurance costs

Press Enter to Go to Next Screen

- ( iii ) Loss of Process
  - \* Production Loss
  - \* Loss of revenue
  - \* Loss of goodwill
  - \* Contractual problems
  - \* Legal Costs

Accident Grouping

Let us now relate an accident and incident. Where an incident would be an undesired contact with an energy source, example are:-

- |                  |             |                  |               |
|------------------|-------------|------------------|---------------|
| * Struck against | * Struck by |                  |               |
| * Fall to        | * Fall on   |                  |               |
| * Caught on      | * Caught in | * Caught between | * Contact wit |
| * Over stress    | * Over load | * Over exertion  |               |

When any of the foregoing incidents occur and if the contact is above the (pai threshold limit then an accident has taken place. Accidents can be grouped in to :

Press Enter to Go to Next Screen



Unsafe Conditions (working environment)

If we examine accidents caused by unsafe practises, we would find that there have always been:-

- \* Failure to warn
- \* Failure to obey rules
- \* Failure to follow work procedures
- \* Removal of safety protection
- \* Improper lifting
- \* Failure to use personal protection equipment
- \* Non servicing of operating equipment
- \* Horseplay
- \* Under influence of alcohol/drugs
- \* Operating equipment without authority

Press Enter to Go to Next Screen

Further examination of accidents when caused by unsafe conditions, we would find that the working environment was populated by, examples of :-

- \* Inadequate guards on barriers
- \* Defective tools and equipment
- \* work congestion
- \* Inadequately supplied personal protection equipment
- \* Inadequate warning systems
- \* Fire/Explosion hazards
- \* Excessive or lengthy exposure to - Noise, Radiation
- \* Inadequate lighting
- \* Poor housekeeping
- \* Poor ventilation

Press Enter to Go to Next Screen

## Causes of Accidents

Having looked at unsafe acts and unsafe conditions and suggested what is likely to be the cause of accidents within these two areas. Let us now look at the symptoms or basic causes i.e. Personal factors and the Work factors.

- 4.1 Personal factors:-
  - \* Square pegs in round holes and inadequate capability, physically and mentally unsuited
  - \* Lack of knowledge
  - \* Lack of skill
  - \* Stress (in the job or at home)
  - \* Incorrect motivation
- 4.2 Work factors-An inadequacy in :-
  - \* Management/Leadership
  - \* Engineering design
  - \* Supervisory indifference
  - \* Tools and equipment
  - \* Work method appraisal
  - \* Planned work approach
  - \* Abuse and misuse
  - \* Inspection

Press Enter to Go to Next Screen

## The Cost of Accidents

Apart from the unacceptable human harm that accidents cause undoubtedly accidents cost money and unquestionably they cause loss in profit within companies someone has to pay.

Over the preceding 10 year period, clients have made major changes in the management of safety, brought about by what is seen to be a short fall in profit experienced by those companies not practising safety management to its fullest.

Accidents cost money, though we have seen that it is difficult to quantify exactly how much. Obviously, accident severity features in the cost evaluation. In 1985

The main point of accident costs is that they are controllable and therefore reducible by good Active Accident Prevention Management, sadly lacking in some sectors of British Project Construction Industry. However this is changing as boardrooms are beginning to wake up to the fact that the average cost of an accident impacts on company profit margins.

Press Enter to Go to Next Screen

#### SAFETY MANAGEMENT - LOSS CONTROL

The Preceding information has hopefully demonstrated that accidents have a significant cost implication for companies and more specifically for projects. There is always the moral and ethical argument that we should work towards zero accidents. Because as managers, we have a duty of care for our employees.

There is also the financial case to put to Directors, that zero accidents should be pursued on a wider strategy of shareholder interest and management financial control to help reduce company's operating cost. In short, a zero accidents policy is very good business practice.

Unfortunately some project managers tend to focus on tangible costs; the cost of compliance, very often the minimum that Legislation requires. Further they consider safety expenditure as a drain on budget and do not see the economic advantage of improving site safety standards.

At some point "A" investment in safety does not give a net return, few, if any UK companies would appear to have reached this point and many see a need to further invest in the management loss control.

Press Enter to Go to Next Screen

General duties of:- Employees, Employers, Supervisors, Designers  
It shall be the duty of every employee while at work to take reasonable care for the health and safety of himself and other persons who may be affected by his acts or omissions at work; and as regards any duty or requirement-imposed on him by or under any of the relevant statutory provisions, to co-operate with him so far as is necessary to enable that duty requirement to be performed or complied with.

Employers must ensure as far as is reasonably practicable, the health, safety and welfare of work of their employees.

The planning supervisor's duty is closely related to the client in that the planning supervisor must be competent to formulate advice to the client on adequacy of the time and finance allowed for the project, but that it is the client who must decide the overall specification and provide the necessary money.

Also the health and safety file must be prepared by the planning supervisor then reviewed amended or added to the principal contractor

Designers have duties to conduct their undertakings in such a way as to ensure that persons not in their employment are not exposed to risks to their safety.

Press Enter to Go to Next Screen

## SAFETY MANAGEMENT

You may now start the general knowledge section evaluation test

Press ENTER to go to next screen

Safety Management (General evaluation section)

Q1. Accident is defined in safety management as :

- A  
All undesired circumstances and near misses  
which have the potential to cause accidents
- B  
The potential to cause harm, including ill  
health and injury; damage to property, plant,  
products or the environment; production  
losses or increased liabilities.
- C  
An undesired event which give rise to  
ill health or injury; damage to property, plant,  
products or the environment; production losses  
or increased liabilities.
- D  
The likelihood that a specified undesired event  
will occur due to the realisation of a hazard by,  
or during work activities or by the products  
and services created by work activities.

Please highlight your answer & Press ENTER to go to next screen

Safety Management (General evaluation section)

Q1. Accident is defined in safety management as :

- A  
All undesired circumstances and near misses  
which have the potential to cause accidents
- B  
The potential to cause harm, including ill  
health and injury; damage to property, plant,  
products or the environment; production  
losses or increased liabilities.
- C  
An undesired event which give rise to  
ill health or injury; damage to property, plant,  
products or the environment; production losses  
or increased liabilities.
- D  
The likelihood that a specified undesired event  
will occur due to the realisation of a hazard by,  
or during work activities or by the products  
and services created by work activities.

Please highlight your answer & Press ENTER to go to next screen

Öäääç  
° ! ° Incorrect answer  
ääääî

Q1. Accident is defined in safety management as :

- { A }  
All undesired circumstances and near misses  
which have the potential to cause accidents
- { B }  
The potential to cause harm, including ill  
health and injury; damage to property, plant,

products or the environment; production losses or increased liabilities.

{ C }

An undesired event which give rise to ill health or injury; damage to property, plant, products or the environment; production losses or increased liabilities.

{ D }

The likelihood that a specified undesired event will occur due to the realisation of a hazard by, or during work activities or by the products and services created by work activities.

-----  
The correct answer is { C }

Safety Management (General evaluation section)

Q2 Hazard is defined in safety management as :

A

All undesired circumstances and near misses which have the potential to cause accidents

B

The potential to cause harm, including ill health and injury; damage to property, plant, products or the environment; production losses or increased liabilities.

C

Any undesired event which give rise to ill health or injury; damage to property, plant, products or the environment; production losses or increased liabilities.

D

The likelihood that a specified undesired event will occur due to the realisation of a hazard by, or during work activities or by the products and services created by work activities.

Please highlight your answer & Press ENTER to go to next screen

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° ° Right answer ° °  
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Press ENTER to go to next screen

Safety Management (General evaluation section)

Q3 Incidents defined in safety management as :

A

All undesired circumstance and near misses which have the potential to cause accident

B

The potential to cause harm, including ill health and injury; damage to property, plant, products or the environment; production losses or increased liabilities.

C

Any undesired circumstances which give rise to ill health or injury; damage to property, plant, products or the environment; production losses or increased liabilities.

D

The likelihood that a specified undesired event will occur due to the realisation of a hazard by, or during work activities or by the products and services created by work activities.

Please highlight your answer & Press ENTER to go to next screen

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° ° Right answer ° °  
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Press ENTER to go to next screen





Safety Management (General evaluation section)

Q5      The safety assessment which is carried out by the employer should identify the measures needed to comply with the relevant statutory provisions.

A   True

B   False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q5      The safety assessment which is carried out by the employer should identify the measures needed to comply with the relevant statutory provisions.

{A}   True

{B}   False

-----  
The correct answer is   { A }

Safety Management (General evaluation section)

Q6 Employers must introduce appropriate arrangements for :

- A Effective planning
- B Organisation
- C Control monitoring
- D Review of the preventative measures
- E Protective measures
- F All of the above

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q6 Employers must introduce appropriate arrangements for :

- {A} Effective planning
- {B} Organisation
- {C} Control monitoring
- {D} Review of the preventative measures
- {E} Protective measures
- {F} All of the above

-----  
The correct answer is { F }

Safety Management (General evaluation section)

Q7      The Planning supervisor must be competent to assess the project  
and formulate advice to the client on whether the time and  
finance are adequate

a    True

b    False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q7      The Planning supervisor must be competent to assess the project  
and formulate advice to the client on whether the time and  
finance are adequate

{A} True

{B} False

-----  
The correct answer is   { A }

Safety Management (General evaluation section)

Q8 The information which the client needs to provide:

- A Is that will enable the Planning Supervisor to develop the health and safety plan to comply with his duty.
- B Concerns the premises at which the construction work will be carried out.
- C Will include any health and safety file relating to the structure.
- D All of the above

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q8 The information which the client needs to provide:

- {A} Is that will enable the Planning Supervisor to develop the health and safety plan to comply with his duty.
- {B} Concerns the premises at which the construction work will be carried out.
- {C} Will include any health and safety file relating to the structure.
- {D} All of the above

-----  
The correct answer is { D }



Safety Management (General evaluation section)

Q10 The primary aim of safety management is to intervene in the accident causation process and to break the causation chain

a True

b False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q10 The primary aim of safety management is to intervene in the accident causation process and to break the causation chain

{A} True

{A} False

-----  
The correct answer is { A }







## Definitions and Beliefs

Let us begin with definitions and then outline our Safety Management Beliefs.

## Accident

An undesired event that results in harm to people or the environment, damage to property or loss of process.

## Incident

An undesired event which under different circumstances could have resulted in harm to people or the environment, damage to property or loss of process.

## Safety Management Beliefs

- (a) Safety Management is the managed control of accidental loss.
- (b) In a project environment, Safety must be managed; and thus it should have equal managerial status with the project's macro objectives of schedule, budget and quality.
- (c) Safe working practices and due consideration to environment factors are vital to the overall efficiency and success of projects large and small.
- (d) Let us look at accidents purely (but not only) as a loss. We can therefore postulate a "Loss Causation Model" and seek to minimise the loss.
- (e) Accidents and Incidents are seldom, if ever the result of a single event.

Press Enter to Go to Next Screen

If we focus management attention to the objective "minimise loss", we will doubtless reduce accidents but we will also make cost improvements and so maximise profit. Thus, in a project, we maintain our budget performance position

## Form of Accident :

## ( i ) Harm to people

- \* Suffering
- \* Disability
- \* Hardship
- \* Psychological problems
- \* Replacement costs

## ( ii ) Damage to Property

- \* Repairs
- \* Replacement
- \* Insurance costs

Press Enter to Go to Next Screen

- ( iii ) Loss of Process
  - \* Production Loss
  - \* Loss of revenue
  - \* Loss of goodwill
  - \* Contractual problems
  - \* Legal Costs

#### Accident Grouping

Let us now relate an accident and incident. Where an incident would be an undesired contact with an energy source, example are:-

- |                  |             |                  |               |
|------------------|-------------|------------------|---------------|
| * Struck against | * Struck by |                  |               |
| * Fall to        | * Fall on   |                  |               |
| * Caught on      | * Caught in | * Caught between | * Contact wit |
| * Over stress    | * Over load | * Over exertion  |               |

When any of the foregoing incidents occur and if the contact is above the (paid) threshold limit then an accident has taken place. Accidents can be grouped in to :

Press Enter to Go to Next Screen

#### Unsafe Conditions (working environment)

If we examine accidents caused by unsafe practises, we would find that there have always been:-

- \* Failure to warn
- \* Failure to obey rules
- \* Failure to follow work procedures
- \* Removal of safety protection
- \* Improper lifting
- \* Failure to use personal protection equipment
- \* Non servicing of operating equipment
- \* Horseplay
- \* Under influence of alcohol/drugs
- \* Operating equipment without authority

Press Enter to Go to Next Screen

Further examination of accidents when caused by unsafe conditions, we would find that the working environment was populated by, examples of :-

- \* Inadequate guards on barriers
- \* Defective tools and equipment
- \* work congestion
- \* Inadequately supplied personal protection equipment
- \* Inadequate warning systems
- \* Fire/Explosion hazards
- \* Excessive or lengthy exposure to - Noise, Radiation
- \* Inadequate lighting
- \* Poor housekeeping
- \* Poor ventilation

Press Enter to Go to Next Screen

#### Causes of Accidents

Having looked at unsafe acts and unsafe conditions and suggested what is likely to be the cause of accidents within these two areas. Let us now look at the symptoms or basic causes i.e. Personal factors and the Work factors.

##### 4.1 Personal factors:-

- \* Square pegs in round holes and inadequate capability, physically and mentally unsuited
- \* Lack of knowledge
- \* Lack of skill
- \* Stress (in the job or at home)
- \* Incorrect motivation

##### 4.2 Work factors-An inadequacy in :-

- \* Management/Leadership
- \* Engineering design
- \* Supervisory indifference
- \* Tools and equipment
- \* Work method appraisal
- \* Planned work approach
- \* Abuse and misuse
- \* Inspection

Press Enter to Go to Next Screen

### The Cost of Accidents

Apart from the unacceptable human harm that accidents cause undoubtedly accidents cost money and unquestionably they cause loss in profit within companies someone has to pay.

Over the preceding 10 year period, clients have made major changes in the management of safety, brought about by what is seen to be a shortfall in profit experienced by those companies not practising safety management to its fullest.

Accidents cost money, though we have seen that it is difficult to quantify exactly how much. Obviously, accident severity features in the cost evaluation. In 1985

The main point of accident costs is that they are controllable and therefore reducible by good Active Accident Prevention Management, sadly lacking in some sectors of British Project Construction Industry. However this is changing as boardrooms are beginning to wake up to the fact that the average cost of an accident impacts on company profit margins.

Press Enter to Go to Next Screen

Basic Section on Safety Management

8

### SAFETY MANAGEMENT - LOSS CONTROL

The Preceding information has hopefully demonstrated that accidents have a significant cost implication for companies and more specifically for projects. There is always the moral and ethical argument that we should work towards zero accidents.

Because as managers, we have a duty of care for our employees.

There is also the financial case to put to Directors, that zero accidents should be pursued on a wider strategy of shareholder interest and management financial control to help reduce company's operating cost. In short, a zero accidents policy is very good business practise.

Unfortunately some project managers tend to focus on tangible costs; the cost of compliance, very often the minimum that Legislation requires. Further they consider safety expenditure as a drain on budget and do not see the economic advantage of improving safety standards.

At some point "A" investment in safety does not give a net return, few, if any UK companies would appear to have reached this point and many see a need to further invest in the management loss control.

Press Enter to Go to Next Screen

## Basic Section on Safety Management

3

General duties of:- Employees, Employers, Supervisors, Designers  
It shall be the duty of every employee while at work to take reasonable care of the health and safety of himself and other persons who may be affected by his acts or omissions at work; and as regards any duty or requirement-imposed on an employer or any other person by or under any of the relevant statutory provisions, to co-operate with him so far as is necessary to enable that duty requirement to be performed or complied with.

Employers must ensure as far as is reasonably practicable, the health, safety and welfare of work of their employees.

The planning supervisor's duty is closely related to the client in that the planning supervisor must be competent to formulate advice to the client on adequacy of the time and finance allowed for the project, but that it is the client who must decide the overall specification and provide the necessary money.

Also the health and safety file must be prepared by the planning supervisor then reviewed amended or added to the principal contractor

Designers have duties to conduct their undertakings in such a way as to ensure that persons not in their employment are not exposed to risks to their safety.

Press Enter to Go to Next Screen

## SAFETY MANAGEMENT

You may now start the Basic knowledge section evaluation test

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q1 What is an accident , is it

- A Harm to people ?
- B Damage to property ?
- C Loss of process ?
- D All of the above

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer  
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Q1 What is an accident , is it

- { A } Harm to people
- { B } Damage to property
- { C } Loss of process
- { D } A. B. & C.

-----  
The correct answer is { D } A. B. & C.

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q2        If a person has an accident , does the person

- A        Suffer harm.
- B        have disability.
- C        Hardship.
- D        Have Psychological problems.
- E        Get compensation.
- F        Need to be replaced.
- E        All of the above

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q2        If a person has an accident , does the person

- { A }     Suffer harm.
- { B }     have disability.
- { C }     Hardship.
- { D }     Have Psychological problems.
- { E }     Get compensation.
- { F }     Need to be replaced.
- { E }     All of the above

-----  
The correct answer is { E }     All of the above

Press ENTER to go to next screen



Safety Management (Basic evaluation section)

Q3 Is it an accident when we damage property and equipment and not people

YES

NO

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

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.....  
Q3 Is it an accident when we damage property and equipment and not people

{ YES }

{ NO }

-----  
The correct answer is { YES }

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q4      When we damage property and equipment is there a cost implication  
in :

- A          Repair.
- B          Replacement.
- C          Insurance.
- D          Production loss.
- E          All of the above.

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q4      When we damage property and equipment is there a cost implication  
in :

- { A }      Repair.
- { B }      Replacement.
- { C }      Insurance.
- { D }      Production loss.
- { E }      All of the above.

-----  
The correct answer is { E }      All of the above

Press ENTER to go to next screen



Safety Management (Basic evaluation section)

Q6           What causes an accident , is it ?

- A           Conflict.
- B           Stupidity.
- C           In-discipline.
- D           Incidents.

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q6           What causes an accident , is it ?

- { A }      Conflict.
- { B }      Stupidity.
- { C }      In-discipline.
- { D }      Incidents.

-----  
The correct answer is { D }   Incidents..

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q7    An incident is an undesired contact with an energy source..

Yes

NO

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

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.....  
Q7    An incident is an undesired contact with an energy source..

{ Yes }

{ NO }

-----  
The correct answer is { Yes }

Press ENTER to go to next screen



Safety Management (Basic evaluation section)

Q9      What is the immediate causes of an incident that can become an  
         accident, is it :

- A      Substandard practices.
- B      Substandard work conditions.
- C      All of the above.

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q9      What is the immediate causes of an incident that can become an  
         accident, is it :

- { A }   Substandard practices.
- { B }   Substandard work conditions.
- { C }   All of the above.

-----  
The correct answer is   { C }   All of the above.

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q10      The basic symptomatic causes of accidents and incidents can be described as personal factors and work factors.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Press ENTER to go to next screen



Safety Management (Basic evaluation section)

Q11 At Site, construction safety needs control.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

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Q11 At Site, construction safety needs control.

{True }

{False}

The correct answer is {True }

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q12        Site construction safety control depends upon,

- A        a safety program.
- B        safety compliance.
- C        safety standards.
- D        All of the above.

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q12        Site construction safety control depends upon,

- { A }    a safety program.
- { B }    safety compliance.
- { C }    safety standards.
- { D }    All of the above.

-----  
The correct answer is    { D }    All of the above

Press ENTER to go to next screen



Safety Management (Basic evaluation section)

Q14 When an incident occurs do we have a loss

YES

NO

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q14 When an incident occurs do we have a loss

{ YES }

{ NO }

-----  
The correct answer is { YES }

Press ENTER to go to next screen

Safety Management (Basic evaluation section)

Q15 Safety management can contribute to company profitability.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Press ENTER to go to next screen





Safety Management (Intermediate evaluation section)

Q1 When managing safety does the health and safety at work act  
(HSA) require me to :

- A Comply totally.
- B Implement at all cost
- c Do what is reasonably practicable.

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q1 When managing safety does the health and safety at work act  
(HSA) require me to :

- { A } Comply totally.
- { B } Implement at all cost
- { c } Do what is reasonably practicable.

-----  
The correct answer is { c }

Press ENTER to go to next screen



Safety Management (Intermediate evaluation section)

Q2 I can delegate the legal responsibilities for ensuring that  
employees and contractors follow safe working practices.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q2 I can delegate the legal responsibilities for ensuring that  
employees and contractors follow safe working practices.

{True }

{False}

-----  
The correct answer is {False}

Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

Q3 Health and safety are separate issues !

True

False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q3 Health and safety are separate issues !

{True }

{False}

-----  
The correct answer is {False}

Press ENTER to go to next screen



Safety Management (Intermediate evaluation section)

Q5 Indicate two of the following which are not identified in the H.S.W.A. requiring personal protection clothing and equipment.

- A . Eyes, Head and neck.
- B . Heart & Liver.
- C . Hearing & Respiratory system.
- D . Hands and arms & Feet and legs

(H.S.W.A :- Health, Safety and welfar of work of all thier employee).

Please highlight your answer & Press ENTER to go to next screen

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Q5 Indicate two of the above which are not identified in the H.S.W.A. as requiring personal protection clothing and equipment.

- {A}. Eyes, Head and neck.
- {B}. Heart & Liver.
- {C}. Hearing & Respiratory system.
- {D}. Hands and arms & Feet and legs

-----  
The correct answer is {B}. Heart & Liver

Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

Q6      The health and safety at work act is the only legal redress  
employees have.

True

False

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q6      The health and safety at work act is the only legal redress  
employees have.

{True }

{False}

-----  
The correct answer is {False}

Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

Q7 An employer will be liable to the employee for injury, loss or damage if the employee can show that the employer was :

Negligent

In breach of statutory duty

Both

Please highlight your answer & Press ENTER to go to next screen

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Q7 An employer will be liable to the employee for injury, loss or damage if the employee can show that the employer was :

{Negligent}

{In breach of statutory duty}

{Both}

-----  
The correct answer is {Both}

Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

- Q8 It is the duty of supervisors at work to ensure that all persons who use, work equipment have available to them comprehensible and adequate health and safety information and, where appropriate, written instructions on use

True

False

Please highlight your answer & Press ENTER to go to next screen

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- Q8 It is the duty of supervisors at work to ensure that all persons who use, work equipment have available to them comprehensible and adequate health and safety information and, where appropriate, written instructions on use

{True }

{False}

The correct answer is {False}

Press ENTER to go to next screen





Safety Management (Intermediate evaluation section)

Q10      Employers should be able to suitably analyse place of work  
used in the undertaking by users and operators, that is in order to  
assess risks to health and safety, and to reduce risks to the lowest  
extent reasonably practicable

True

False

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q10      Employers should be able to suitably analyse place of work  
used in the undertaking by users and operators, that is in order to  
assess risks to health and safety, and to reduce risks to the lowest  
extent reasonably practicable

{True }

{False}

-----  
The correct answer is {Both}

Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

Q11 The accident report form is the employer's report of injury and must be completed by:

The injured employee

The local management

Please highlight your answer & Press ENTER to go to next screen

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Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

Q12 The current means of addressing safety issues is to asses the:

- A Risk
- B standards necessary to overcome the risk
- C Training of the personnel involved
- D All of the above

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer  
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.....  
Q12 The current means of addressing safety issues is to asses the:

- {A} Risk
- {B} standards necessary to overcome the risk
- {C} Training of the personnel involved
- {D} All of the above

-----  
The correct answer is {D} All of the above

Press ENTER to go to next screen

Safety Management (Intermediate evaluation section)

Q13 Does H.S.W.A. place a duty on employees to :

- A Take reasonable care .
- B Avoid injury to themselves and others.
- c Co-operate with employers in meeting the statutory requirements.
- D All of the above.

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

Q13 Does H.S.W.A. place a duty on employees to :

- { A } Take reasonable care .
- { B } Avoid injury to themselves and others.
- { c } Co-operate with employers in meeting the statutory requirements.
- { D } All of the above

-----  
The correct answer is { D } All of the above

Press ENTER to go to next screen











## Introduction

1994 saw the introduction of European legislation affecting construction design and safety management and became law in 1995.  
The new legislation is designed to improve the management of Health and Safety on mobile construction sites.  
The legislation stems from proposals to implement the directives made under the article 118A of the Treaty of Rome.  
The European Commission has a view that more than half of the occupational.

## Principal Aim of the design and safety management legislation

To raise safety standards in the construction industry across the European Community.

Press Enter to Go to Next Screen

## Principal Effects

Redistribute and restore balance in the Criminal Law and duties on the parties involved in construction projects.  
To ensure the necessary time and financial provision is provided for safe construction.  
To clarify the responsibilities for notification, planning, co-ordination and control of project activities.  
To establish the requirements for proactive and integrated safety planning process and associated documentation.

## Implementation

The implementation of the legislation involved the clients and developers, planning supervision, principal contractor, designer, other contractors.

Press Enter to Go to Next Screen

Clients and Developers duties

Appointment of :-  
Planning Supervisor and Principal Contractor.  
Give notice of Project.  
Make adequate financial budget provision.  
Ensure that schedule does not impact on good safe working practice.  
Ensure competence level of appointees.  
Provide information.

Planning Supervisor's duties

Ensure design can be safely, constructed, repaired and maintained.  
Prepare Project Safety Plan.  
Ensure adequate money and time is allowed.  
Ensure Health and Safety file is prepared for each structure containing information necessary for safe construction.  
Complete safety file and deliver to client.

Press Enter to Go to Next Screen

Principal Contractors Duties and Powers.

- Take over Health and Safety Plan, implement, develop and administer the plan.
- Ensure that all contractors comply with legal duties and safety plan, give direction and monitor competence.
- Coordination of all activities to ensure safe working environment.
- Ensure that there is co-operation and co-ordination between contractors.
- Prevent unauthorised people entering construction areas.
- Provide training.
- Consultation with employees.
- Display notice of notification of site.

Press Enter to Go to Next Screen





Safety Management (Advance evaluation section)

Q2 Accident prevention depends on:

cultural change

Complete elemination of human error

Both

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q2 Accident prevention depends on:

{cultural change }

{Complete elemination of human error}

{Both }

-----  
The correct answer is {cultural change }

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q3 International Safety Rating System is a safety auditing technique which address the adequacy of:

Employee training

Management and Organisation influences

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q3 International Safety Rating System is a safety auditing technique which address the adequacy of:

{Employee training}

{Management and Organisation influences }

-----  
The correct answer is {Management and Organisation influences }

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q4      Implementaion of a safety policy is not straightforward in spite of the commitment by the executive and senior management and that is due to:

- A      Conflict   at other levels, based on a resistance to change
- B      False assumption that safety is at cost to productivity.
- C      Both.

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q4      Implementaion of a safety policy is not straightforward, In spite of the commitment by the executive and senior management that is due to:

- {A }      Conflict   at other levels, based on a resistance to change
- {B }      False assumption that safety is at cost to productivity.
- {C }      Both.

-----  
The correct answer is   {C }   Both

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q5     Although a policy may be admirable in apparent intention and be polished in both form and style, successful implementation may fail because:

- A     Senior management are only minimally involved in the implementation of the safety policy .
- B     The safety policy is not thoroughly understood below senior levels.
- C     Both.

Please choose an option

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° ! °     Incorrect answer  
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.....  
Q5     Although a policy may be admirable in apparent intention and be polished in both form and style, successful implementation may fail because:

- {A}     Senior management are only minimally involved in the implementation of the safety policy .
- {B}     The safety policy is not thoroughly understood below senior levels.
- {C}     Both.

-----  
The correct answer is   {C }   Both

Press ENTER to go to next screen



Safety Management (Advance evaluation section)

Q6 The success or failure of a particular operation depends upon the competence of the person who is undertaking the task.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Press ENTER to go to next screen

Safety Management (Advance evaluation section)

- Q7 Planning supervisors and principal contractors carry out new functions, created by the construction safety management regulation 1994, which ensures that effective direction and co-ordination of health and safety takes place through the project, from conception to handover.

True

False

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer

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- Q7 Planning supervisors and principal contractors carry out new functions, created by the construction safety management regulation 1994, which ensures that effective direction and co-ordination of health and safety takes place through the project, from conception to handover.

{True }

{False}

-----  
The correct answer is {True}

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q8 General principles of prevention and protection must be applied:

- A By project management when deciding the measures which have to be taken following a risk assessment.
- B By everyone with responsibilities under the regulation when they take decisions which might affect health and safety during the project.
- C Both.

Please highlight your answer & Press ENTER to go to next screen

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.....  
Q8 General principles of prevention and protection must be applied:

- {A} By project management when deciding the measures which have to be taken following a risk assessment.
- {B} By everyone with responsibilities under the regulation when they take decisions which might affect health and safety during the project.
- {C} Both.

-----  
The correct answer is {C} Both

Press ENTER to go to next screen



Safety Management (Advance evaluation section)

Q10 An employer has a common law duty towards his employees to provide:

- a- competent fellow employees
- b- safe and adequate equipment
- c- a safe system of work
- d- a safe place of work and access to that place

a,b,&c

b&d

a,b,c&d

Please highlight your answer & Press ENTER to go to next screen

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Q10 An employer has a common law duty towards his employees to provide:

- a- competent fellow employees
- b- safe and adequate equipment
- c- a safe system of work
- d- a safe place of work and access to that place

{a,b,&c}

{ b&d }

{ a,b,c&d }

-----  
The correct answer is { a,b,c&d }

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q12 It is the employers'duty to frequently revise and up date the safety policy within his organisation.

True

false

Please highlight your answer & Press ENTER to go to next screen

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Incorrect answer

.....  
Q12 It is the employers'duty to frequently revise and up date the safety policy within his organisation.

{True }

{false}

-----  
The correct answer is {True}

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q14      Safety criteria should underpin every decision made by the enterprise and it must be considered as an integral part of day-to-day decision-making.

True

False

Please highlight your answer & Press ENTER to go to next screen

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Safety Management (Advance evaluation section)

Q16 The key functions of safety management are:

- A- Policy and planning
- B- Organisation and communication
- C- Hazard management
- D- Monitoring and control

A & B

B, C & D

All of the above

Please highlight your answer & Press ENTER to go to next screen

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° ! ° Incorrect answer

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.....  
Q16 The key functions of safety management are:

- A- Policy and planning
- B- Organisation and communication
- C- Hazard management
- D- Monitoring and control

{ A & B }

{ B, C & D }

{ All of the above }

-----  
The correct answer is { All of the above }

Press ENTER to go to next screen

Safety Management (Advance evaluation section)

Q17      The organisation's safety procedures:

- A      are founded on shared perceptions of hazards and risks
- B      are necessary and workable
- C      will succeed in preventing accidents
- D      have been prepared following a consultation process with  
         the participation of all employees
- E      are subject to continuous review , involving all personnel
- F      All of the above

Please highlight your answer & Press ENTER to go to next screen

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° ! °      Incorrect answer  
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.....  
Q17      The organisation's safety procedures:

- { A }   are founded on shared perceptions of hazards and risks
- { B }   are necessary and workable
- { C }   will succeed in preventing accidents
- { D }   have been prepared following a consultation process with  
         the participation of all employees
- { E }   are subject to continuous review , involving all personnel
- { F }   All of the above

-----  
The correct answer is      { F }   All of the above

Press ENTER to go to next screen







~~~~~  
□ You have covered all sections on the Expert System.~  
~~~~~

Press ENTER to go to next screen

## **Appendix E**

Evaluation questionnaire of the safety management  
expert system



## The Use of Expert Systems in Training

Expert systems are used widely in the construction industry but not **as** yet within training. Therefore research is being undertaken at Edinburgh University to assess the effectiveness of an expert system within training. The system is an additional resource and is not intended to replace a lecture or a lecturer.

- **This exercise** within the Project Management course is intended :-
  - a- **to improve** your knowledge of Safety Management with the aid of the expert system;
  - b- **to contribute** towards evaluating the expert system.
- **Within the 30 minutes** allocated to each student, you should be able to:
  - a- **read** the first page of this hand-out which provides a background and gives instructions to the exercise;
  - b- **proceed** through the expert system and make a note of the scores achieved on page 2;
  - c- **complete** an evaluation on pages **3, 4 and 5**.

*Please note that your answers are completely confidential*

## Expert System on Safety Management

This Expert System is a rule-based system, known **as** EXSAFE 1.1, and was developed using **a** shell (Crystal4.5). EXSAFE 1.1 contains **four sections**, the **general** section, **basic** section, **intermediate** section, and **advanced** section.

---

You **as** the trainee will **start at the general** section, where you will be taken through an evaluation to determine your present level of knowledge on Safety Management. The system would decide on the next section, and you would cover various levels **up** to the advanced section. **Please do not forget to note the score at the end of each level.** On completion **of** the expert system, please fill in the subsequent feed back questionnaire.

**You will be able to access EXSAFE 1.1 by :-**  
**Highlighting "MS DOS CRYSTAL" icon on project management group 1996.**





## **Section 2: Safety Management Evaluation Tests.**

As you go through the four sections, i.e. general, basic, intermediate and advanced, of the Safety Management expert system, you will be given your scores at the end of each evaluation test.

Please enter them below.

- |   |                |
|---|----------------|
| <b>(a) General section final score</b>      | <b>(.....)</b> |
| <b>(b) Basic section final score</b>        | <b>(.....)</b> |
| <b>(c) Intermediate section final score</b> | <b>(.....)</b> |
| <b>(d) Advanced section final score</b>     | <b>(.....)</b> |

12. An expert system tool in other topics of project management will lead to a better understanding to the subject	1	2	3	4	5
13. I feel that expert system for training is a beneficial tool in both education and industrial settings.	1	2	3	4	5
14. The expert system for training has improved the quality of my knowledge in Safety Management.	1	2	3	4	5
15. I find the evaluation questions within the expert system are easy to understand.	1	2	3	4	5
16. The use of expert system in training can save a lot of time.	1	2	3	4	5
17. Knowledge of Safety Management was not required prior to using the expert system.	1	2	3	4	5
18. I feel that I have improved my knowledge by performing the evaluation training programme.	1	2	3	4	5
19. Doing some reading before using the expert system could help in a deeper understanding of the questions.	1	2	3	4	5
20. The timing of the training program was very good.	1	2	3	4	5
21. Key points in the display forms can be found easily.	1	2	3	4	5
22. Speed of navigation through the expert system was adequate.	1	2	3	4	5
23. Higher training efficiency can be achieved with such an expert system.	1	2	3	4	5
24. I feel more confident in all aspects of Safety Management after going through the expert system.	1	2	3	4	5
25. More display forms on Safety Management are required in the knowledge base.	1	2	3	4	5
26. If I used computers in training I could save time and work.	1	2	3	4	5
27. Expert systems are superior to human in processing information.	1	2	3	4	5
28. More effort is needed from both computer science and project management researchers to build more comprehensive expert systems.	1	2	3	4	5
29. I think the evaluation of trainees after going through a training programme is an important step in achieving higher standards.	1	2	3	4	5
30. Written information in Safety Management should be provided prior to trainee starting the test.	1	2	3	4	5

31. Trainee performance can be easily followed through all sections of the evaluation tests.	1	2	3	4	5
32. It is useful at an early stage to define performance levels in the evaluation .	1	2	3	4	5
33. Wording of questions and options are clear.	1	2	3	4	5
34. The expansion of new technologies is making working conditions better.	1	2	3	4	5
35. I feel that computers are necessary tools in both education and work	1	2	3	4	5
36. I had <b>no</b> earlier experience <b>on</b> the subject of Safety Management.	1	2	3	4	5
37. I felt that the expert system was too difficult for me.	1	2	3	4	5
38. I think Safety Management is still not explored well in engineering areas.	1	2	3	4	5
39. It is important to learn from experts experience	1	2	3	4	5
40. I look forward to computers taking over certain routine tasks.	1	2	3	4	5

---

**Please don't forget to return the questionnaire when you have completed it.**

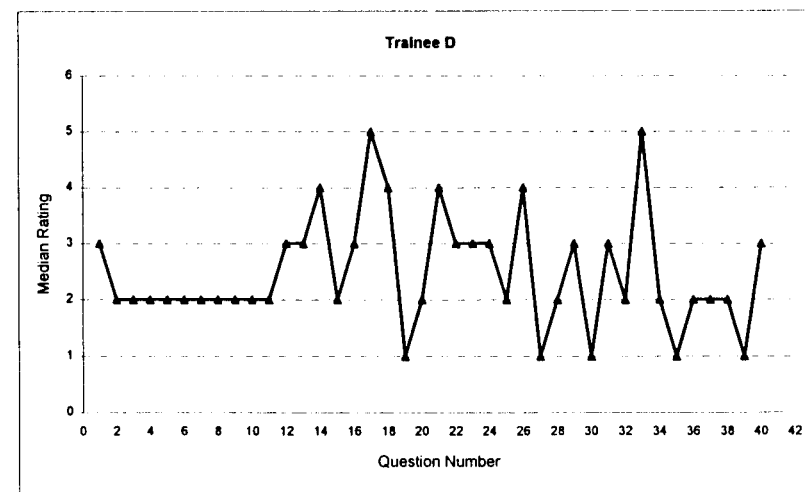
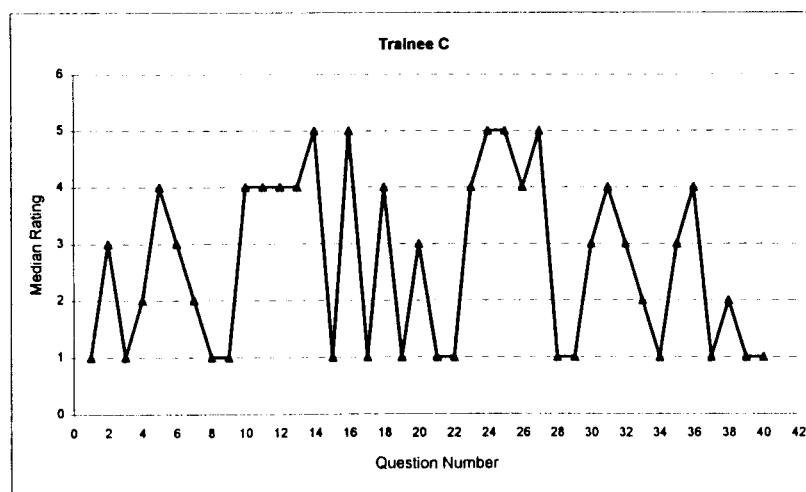
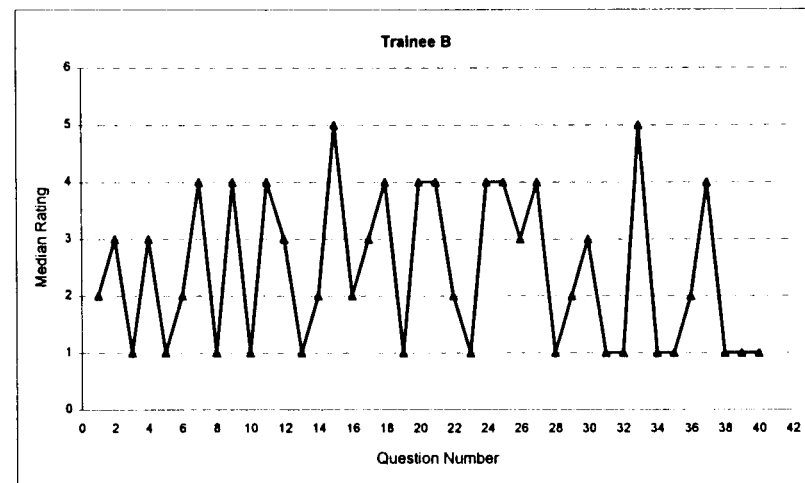
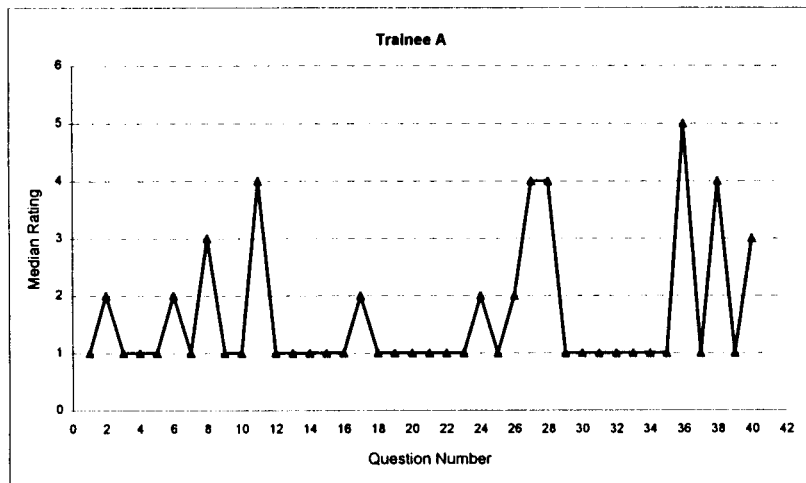
**DO NOT PUT YOUR NAME ANYWHERE ON THIS QUESTIONNAIRE, AS IT IS NOT NECESSARY.**

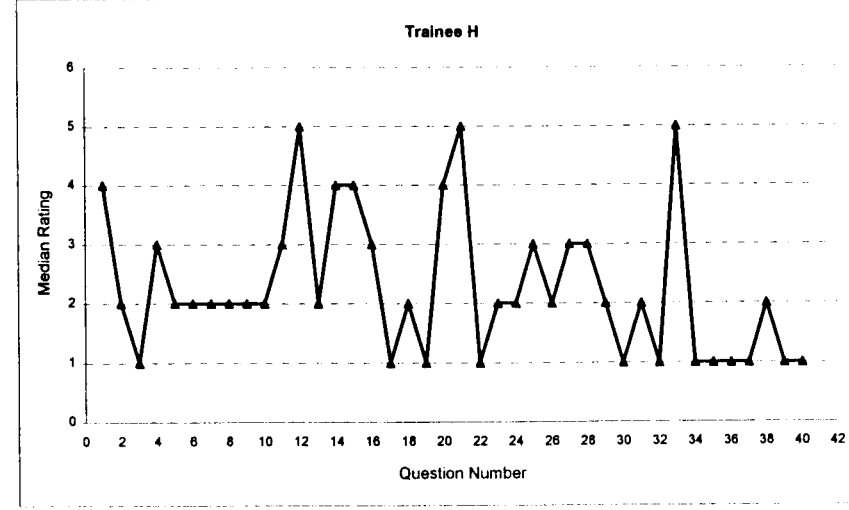
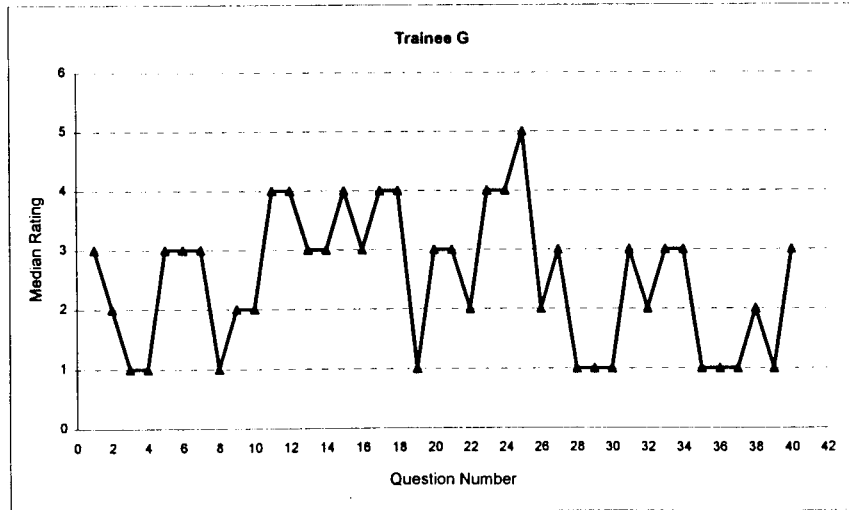
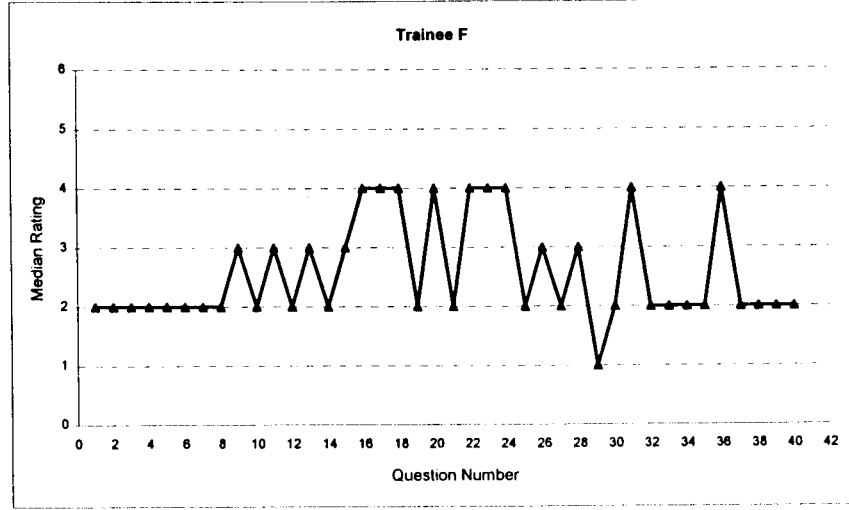
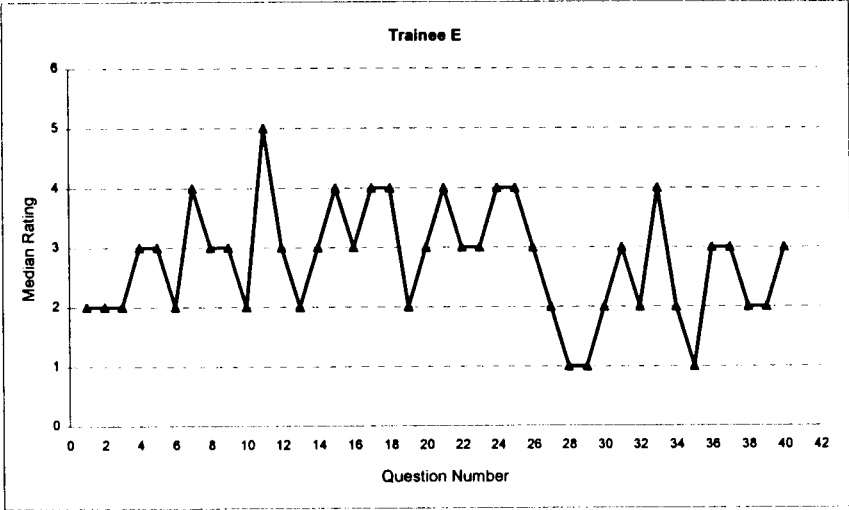
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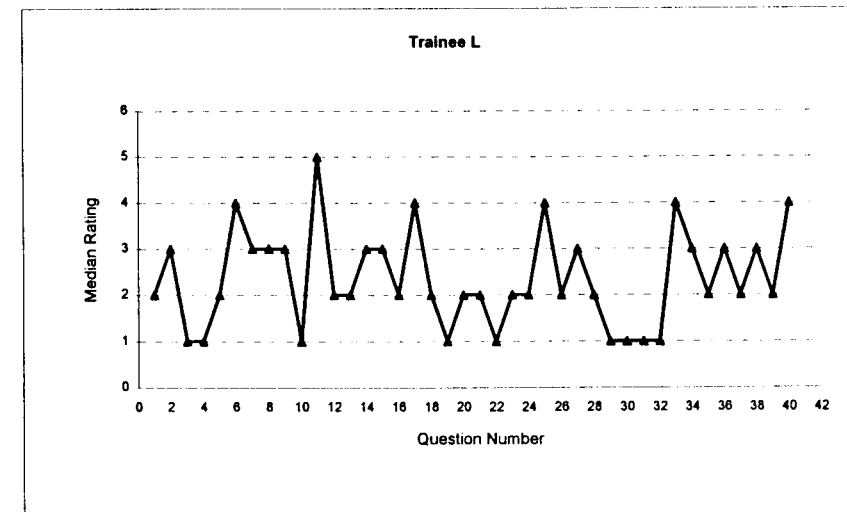
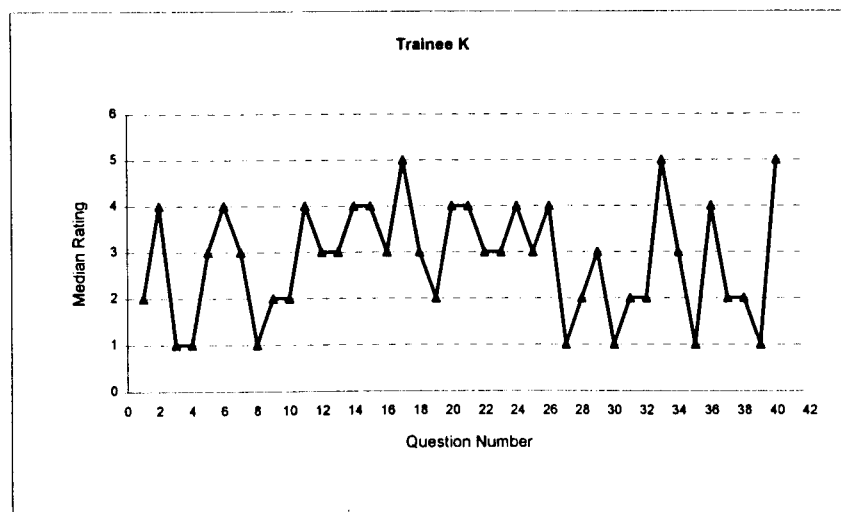
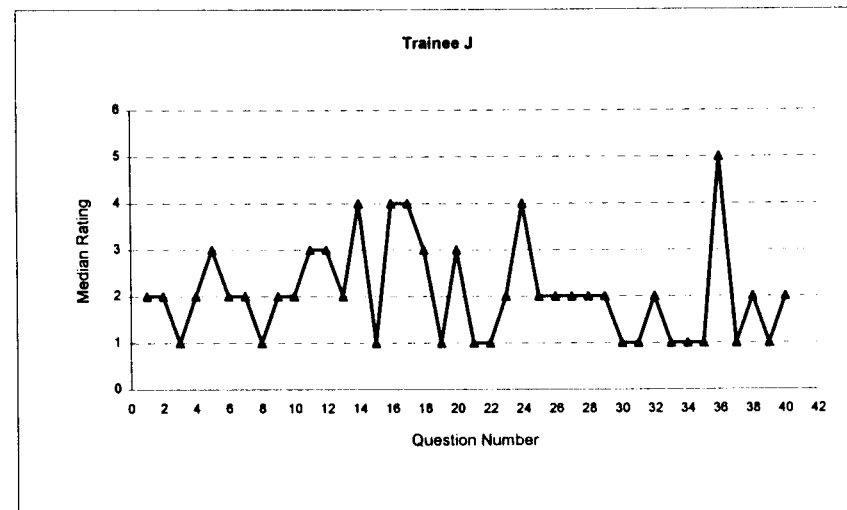
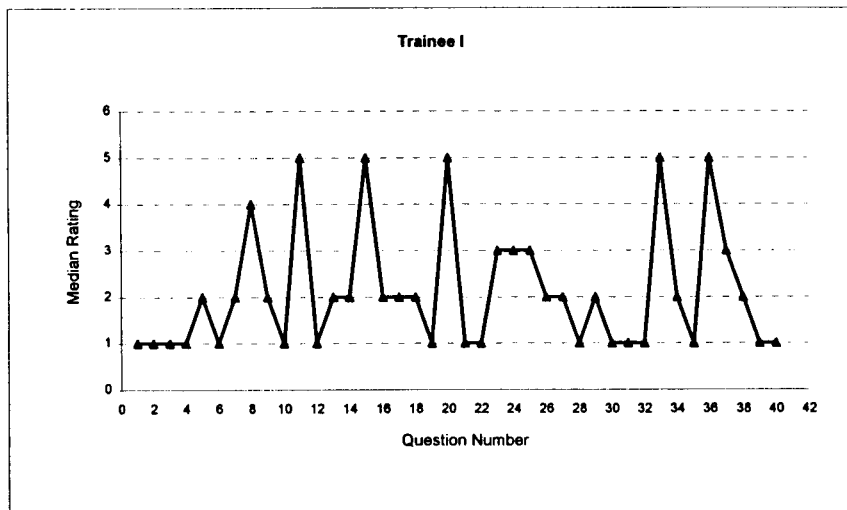
## **Appendix F**

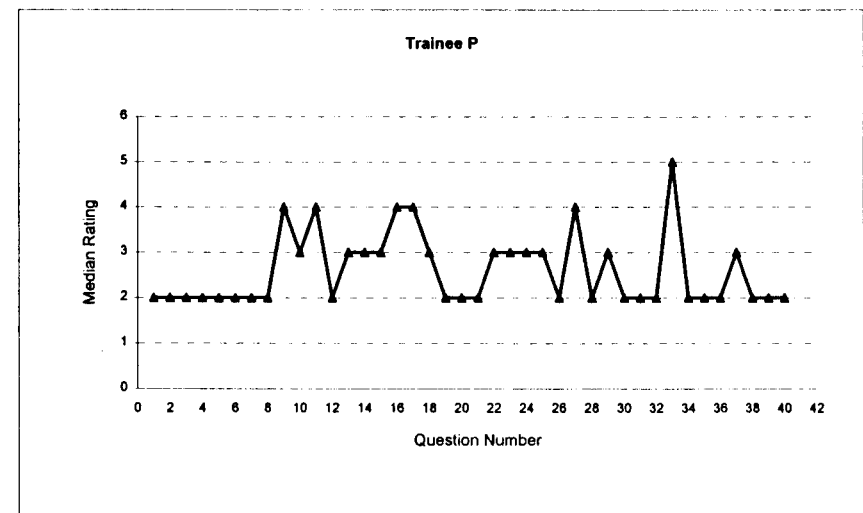
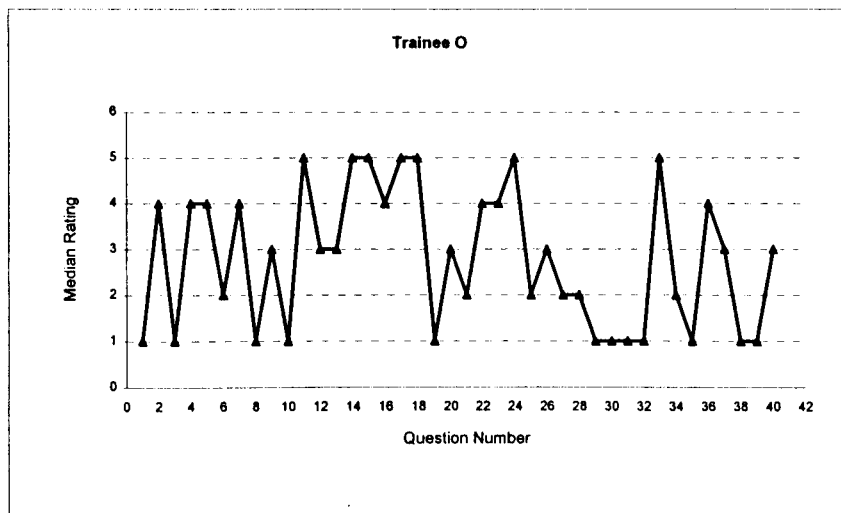
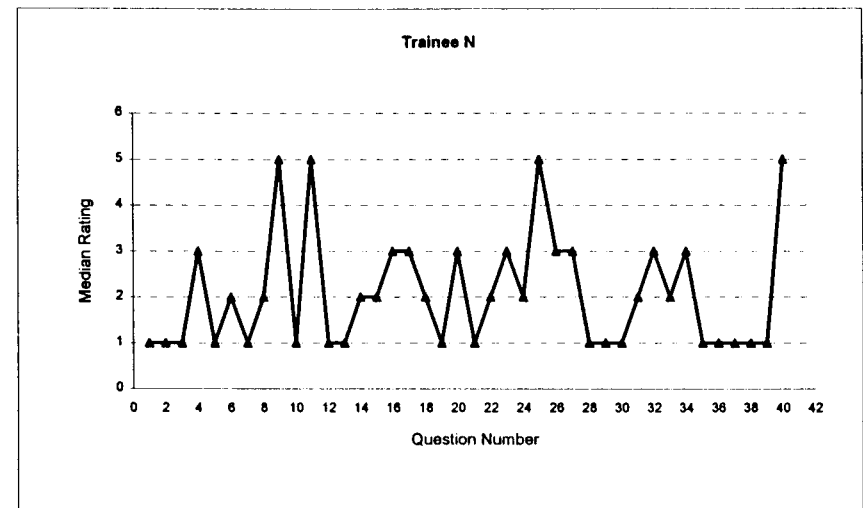
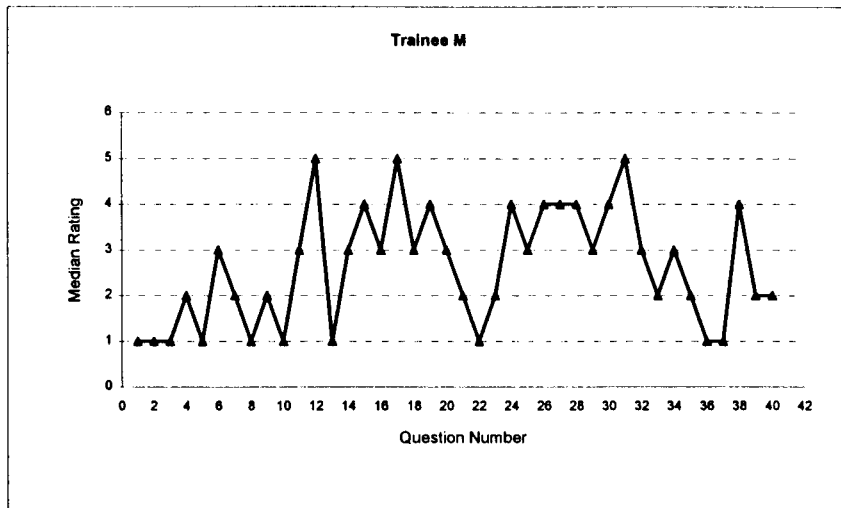
Results of the safety management expert system  
evaluation

## Response of each trainee to all questions

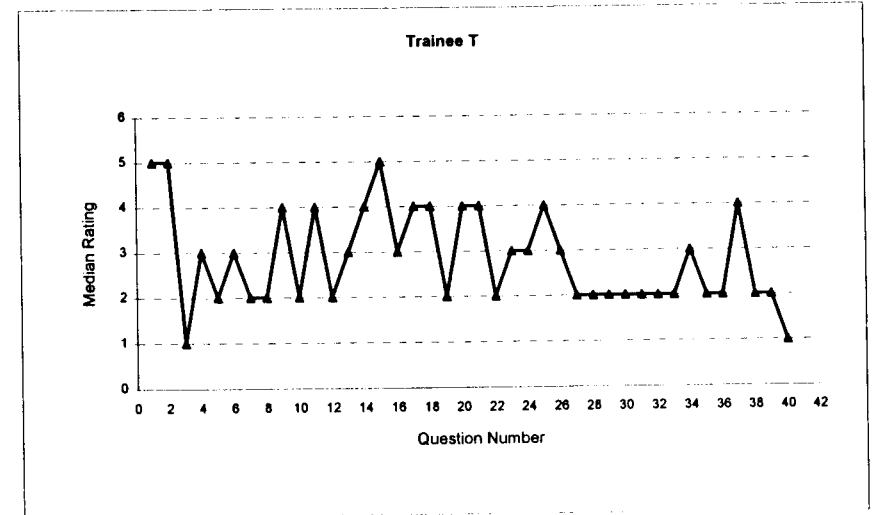
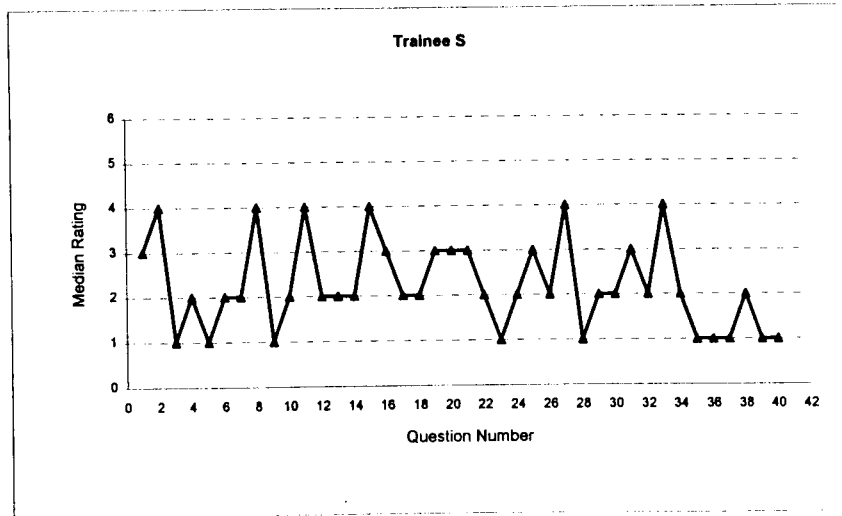
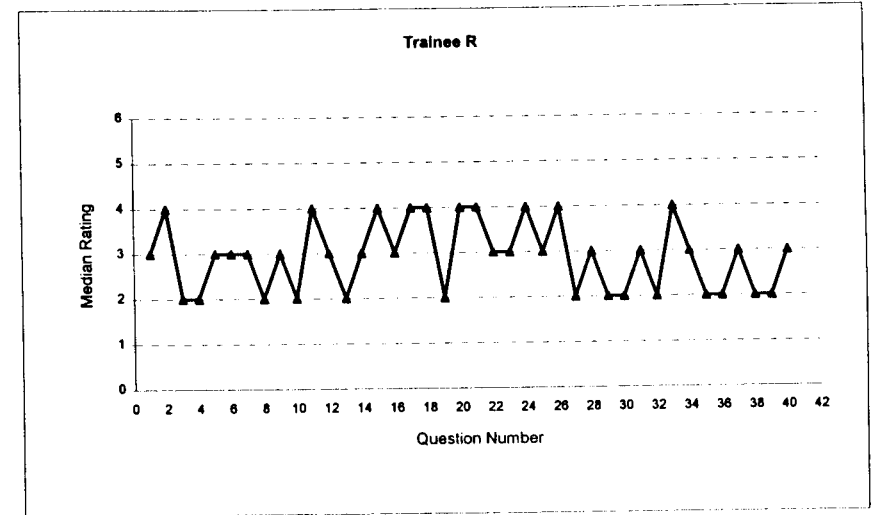
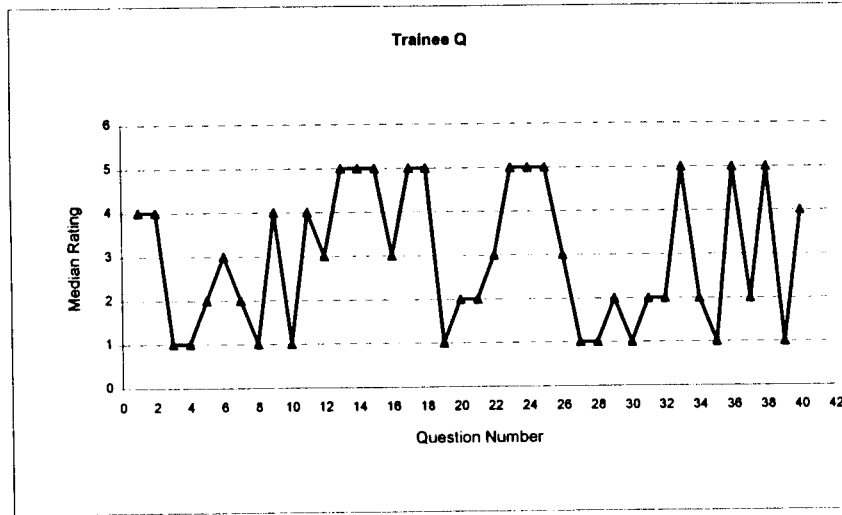


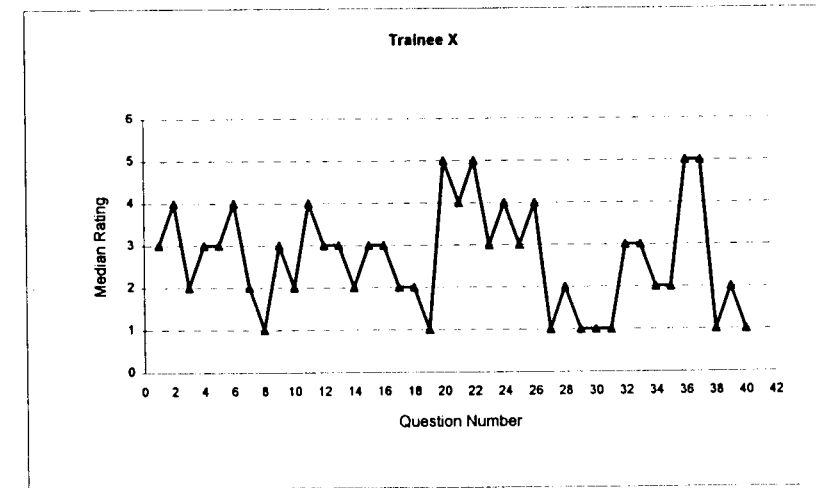
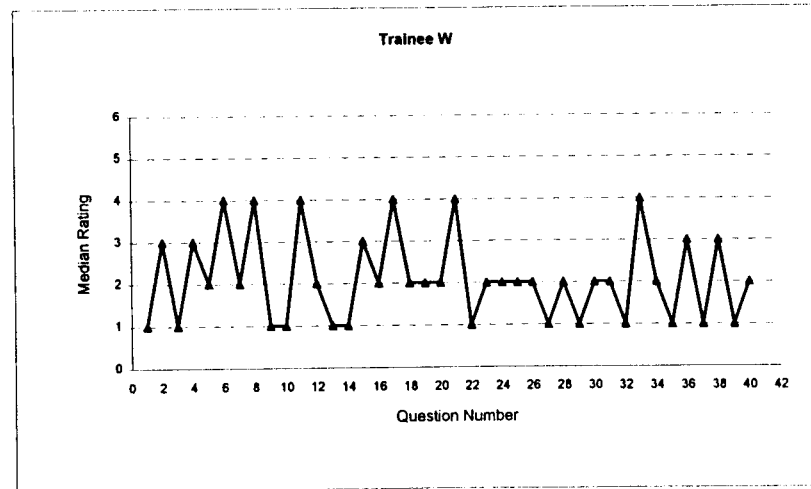
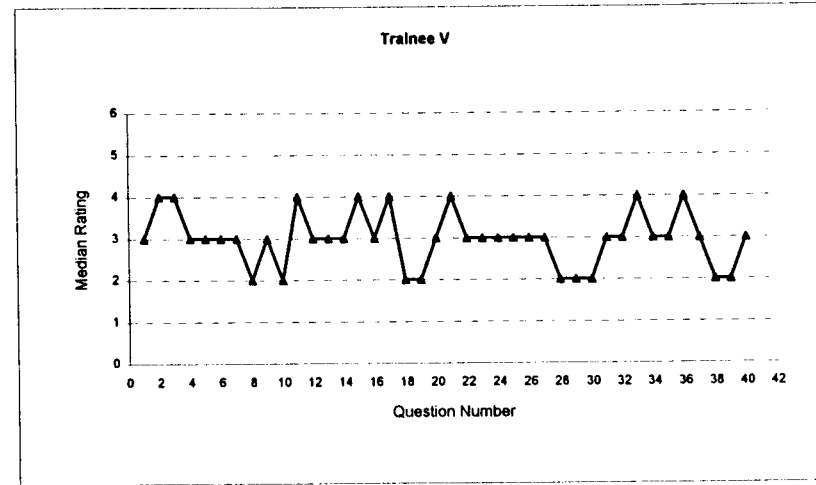
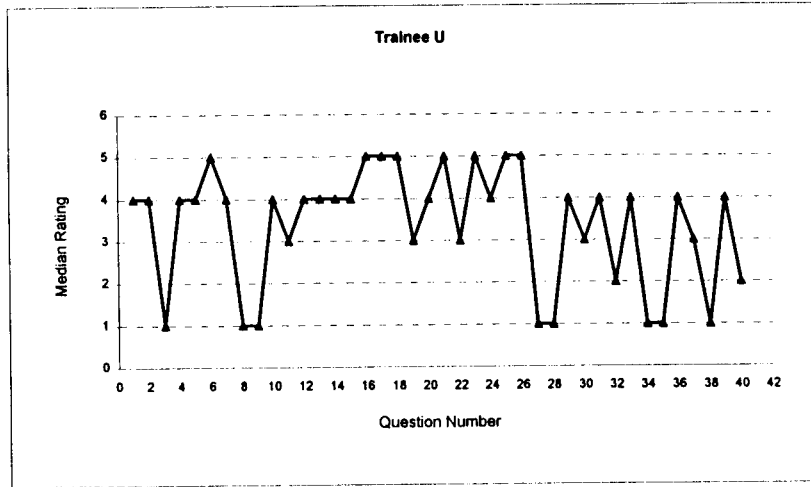


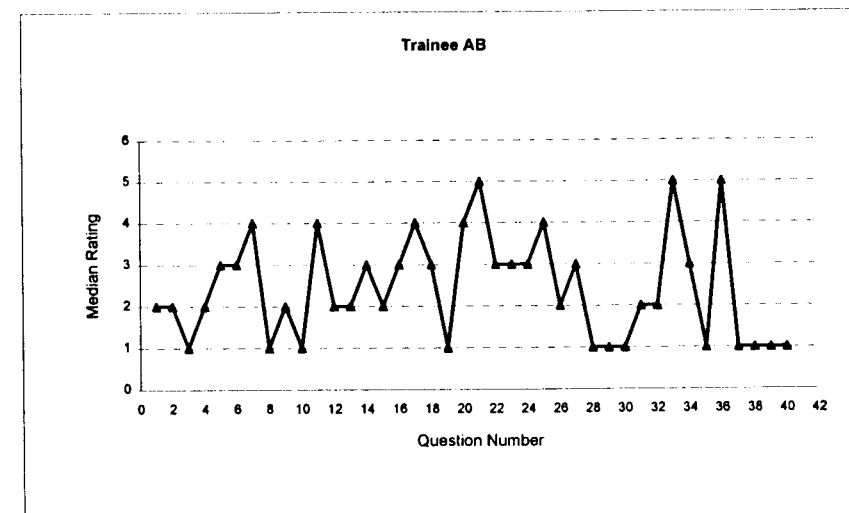
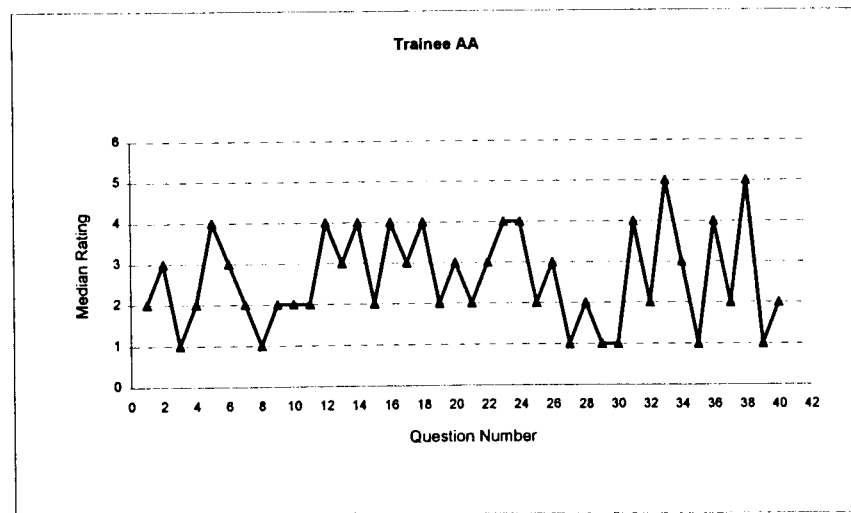
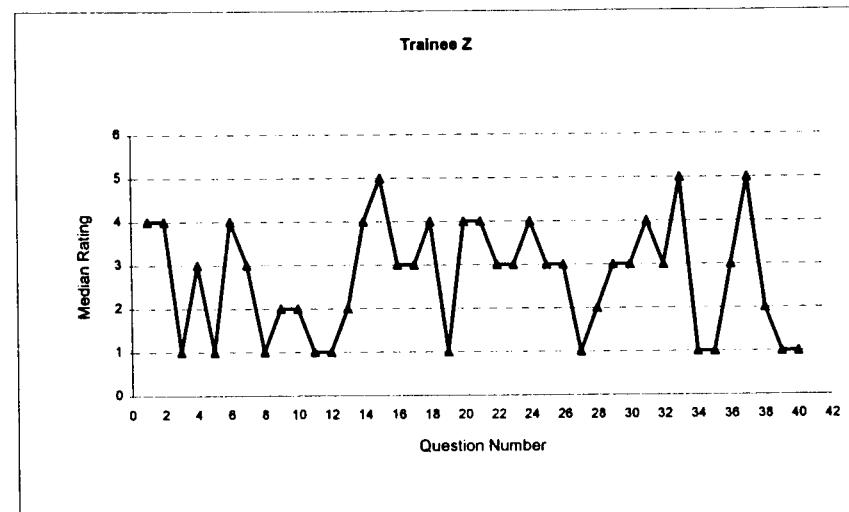
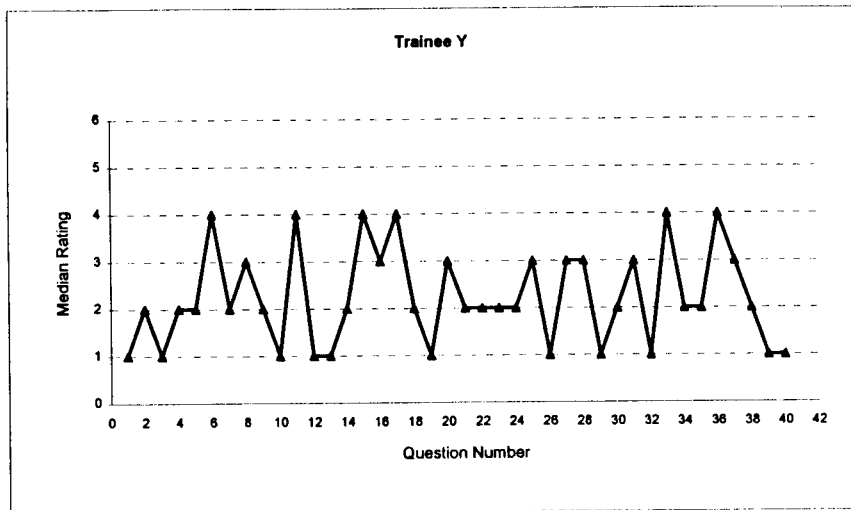


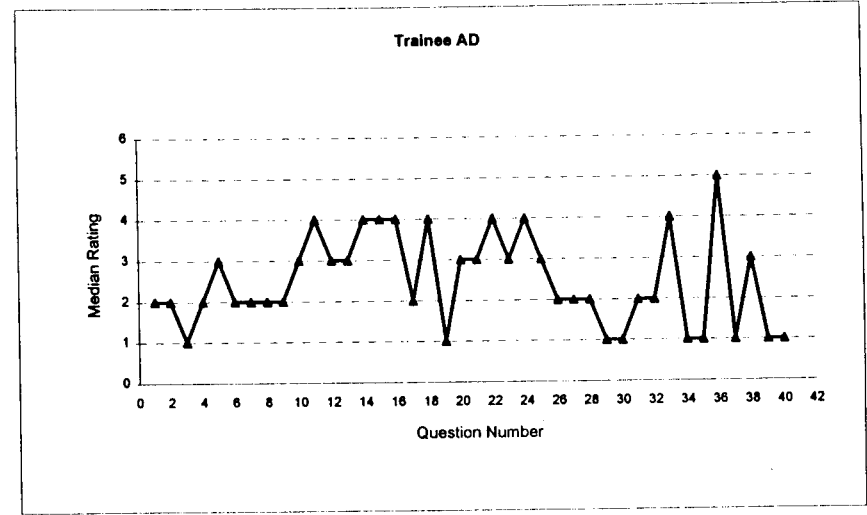
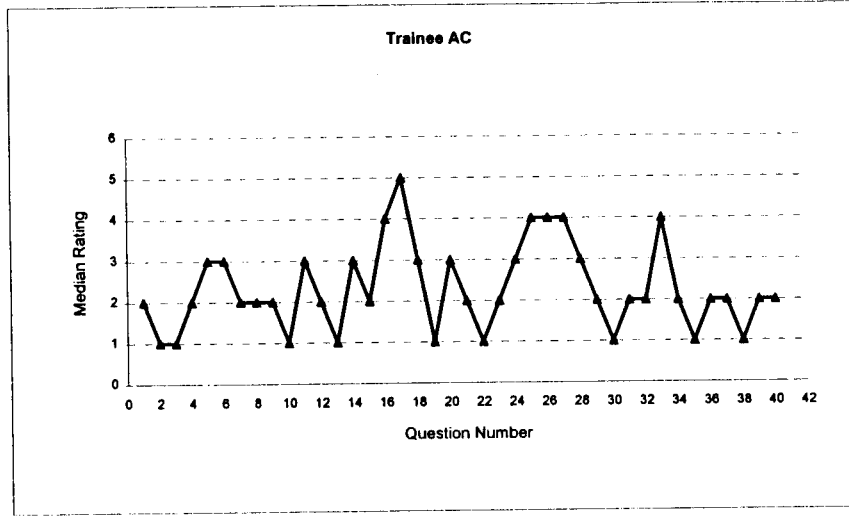




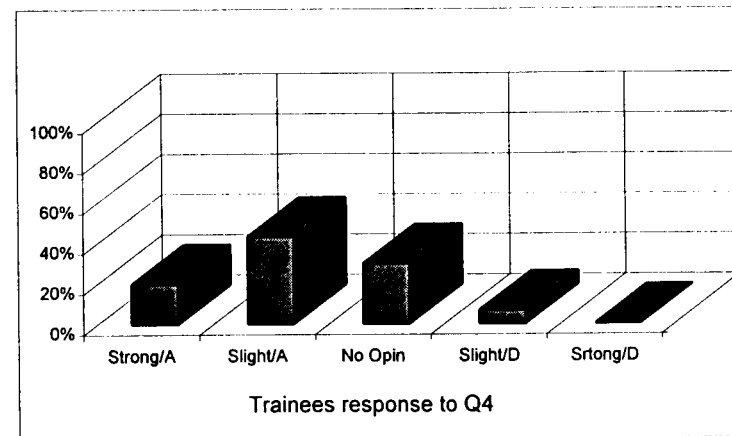
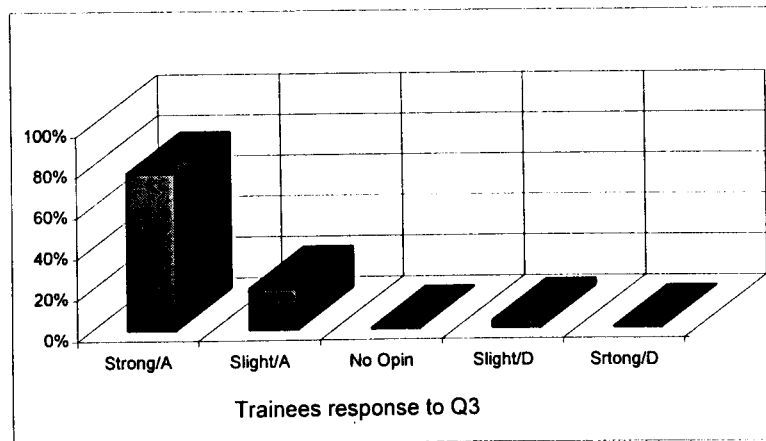
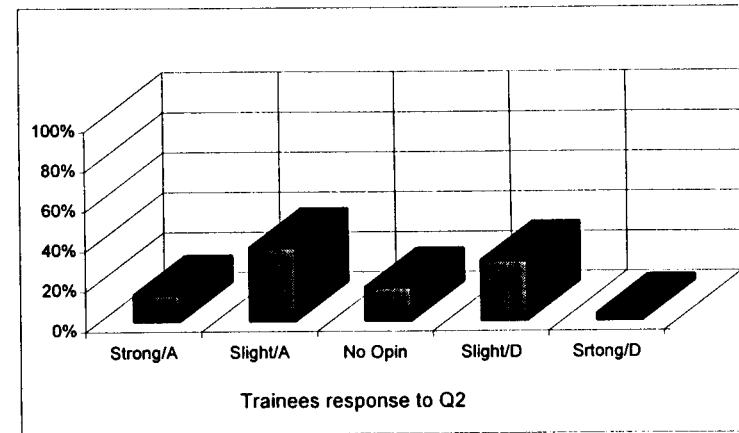
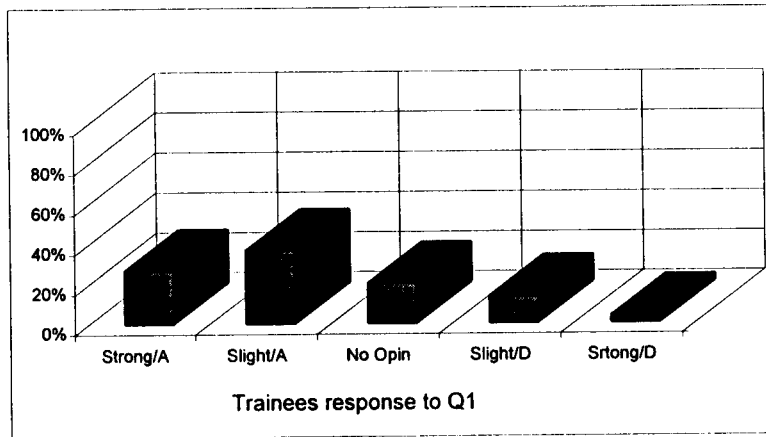


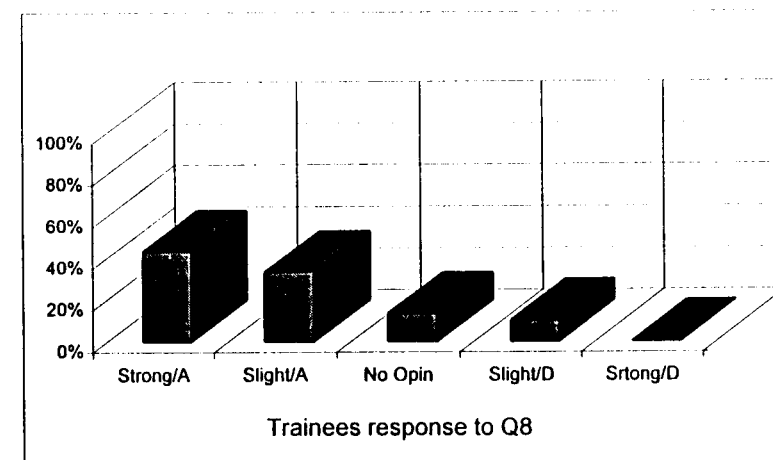
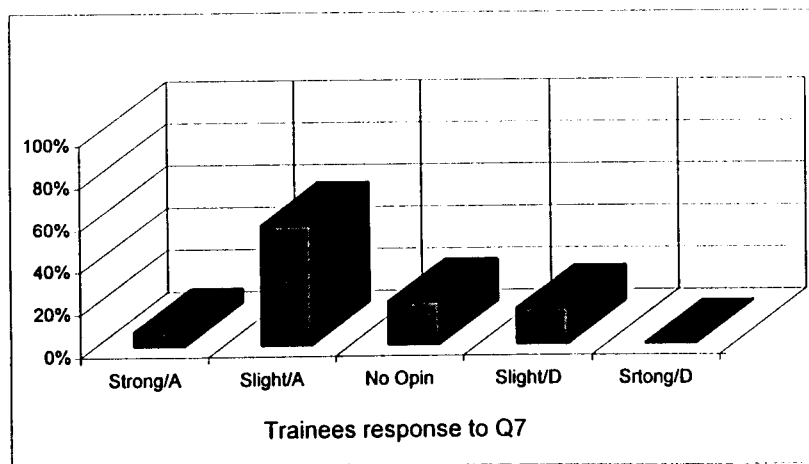
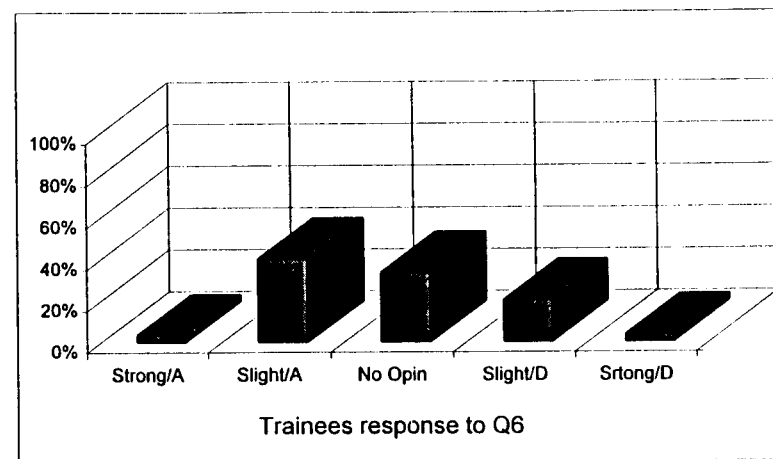
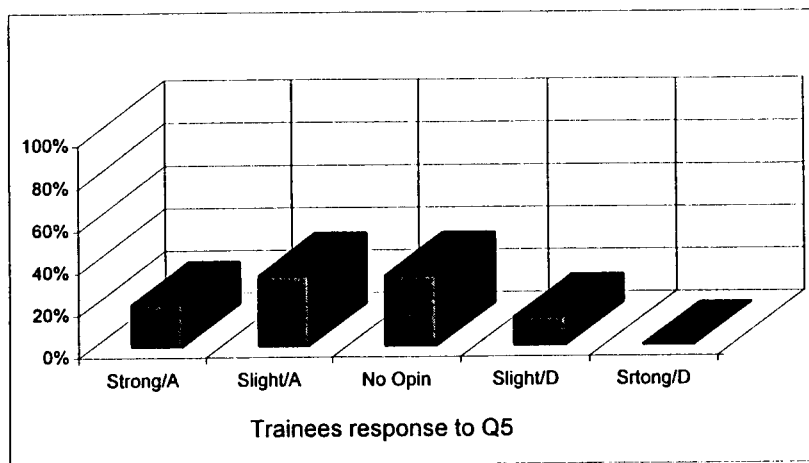


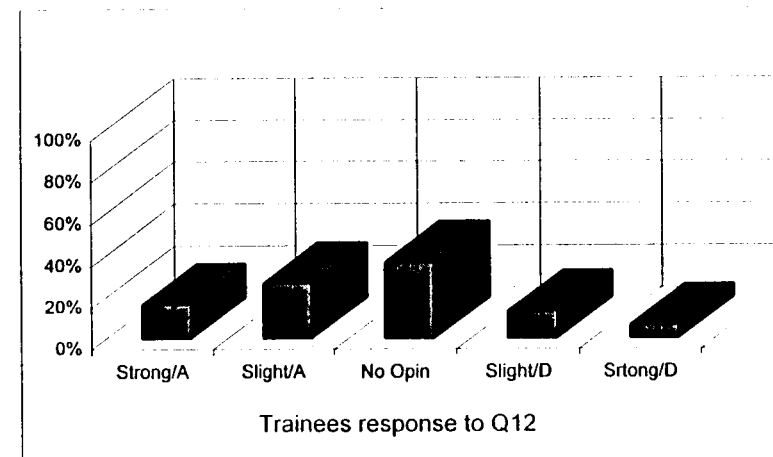
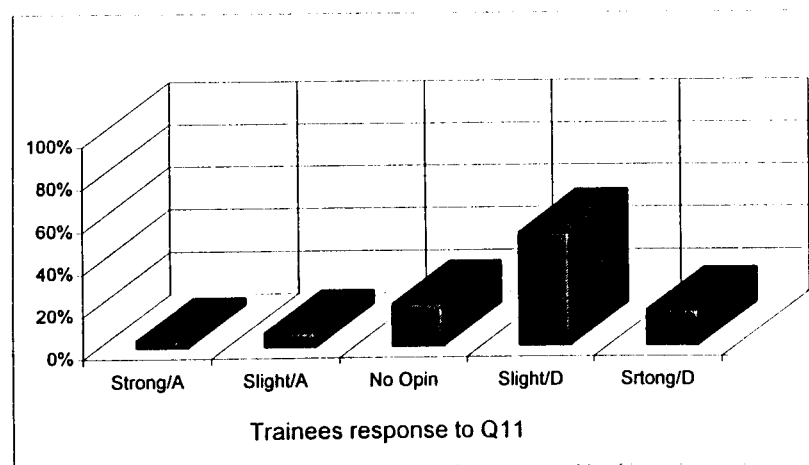
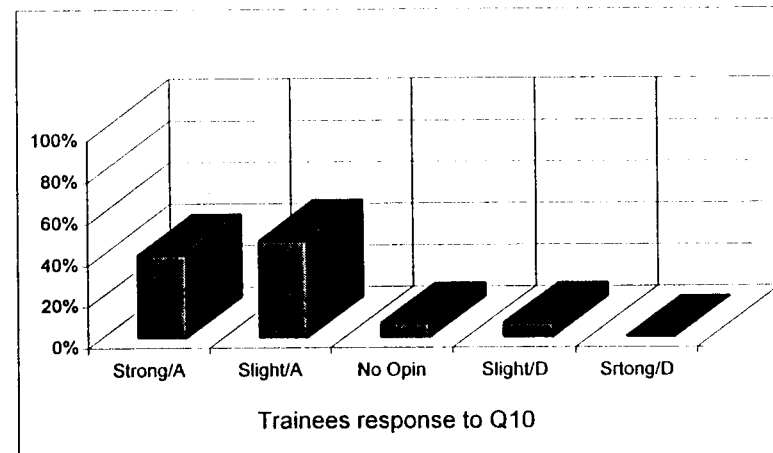
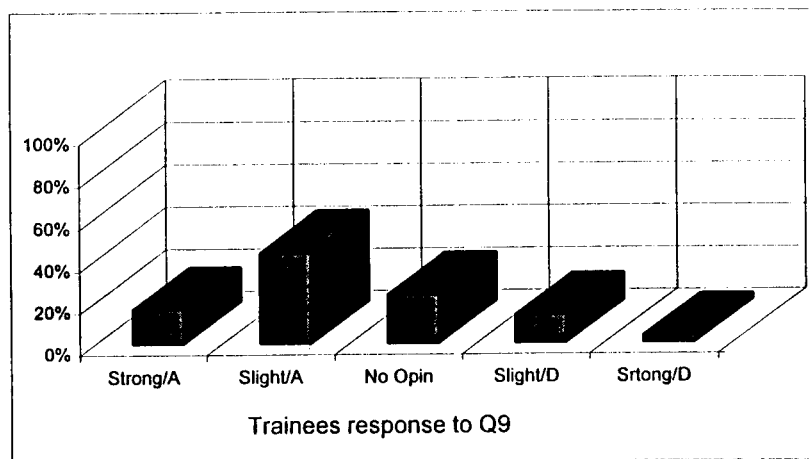


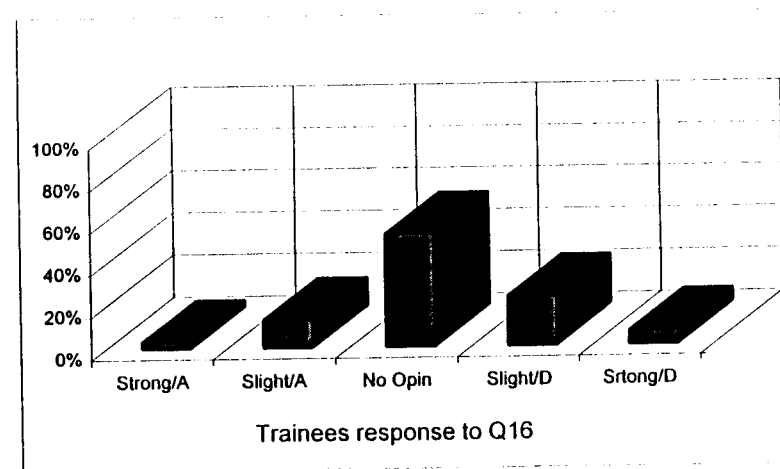
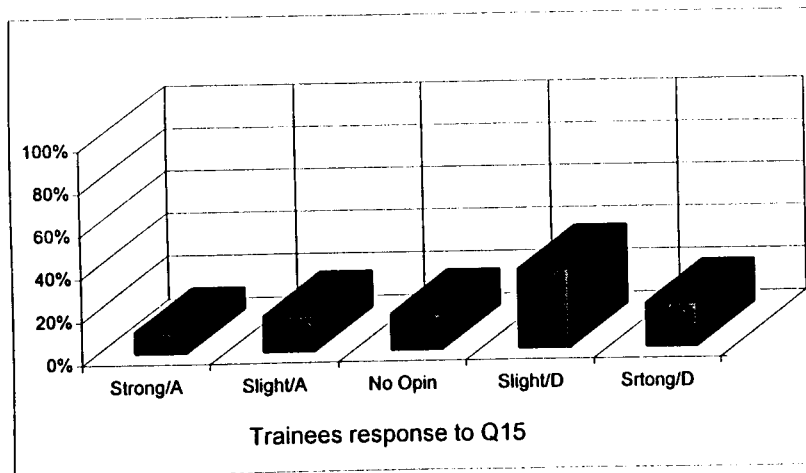
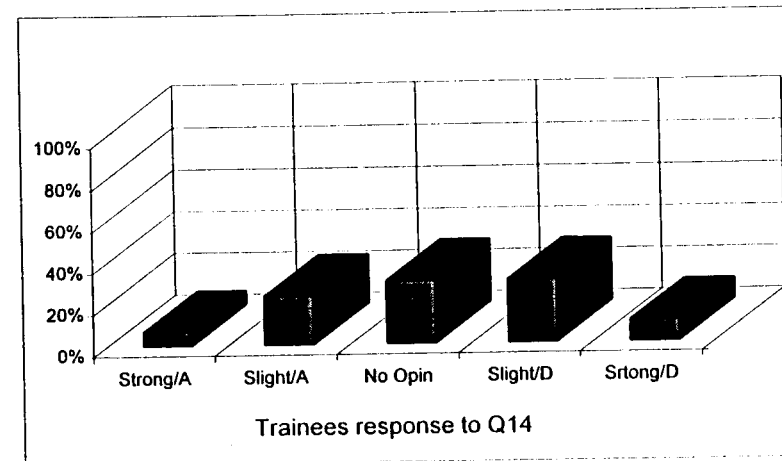
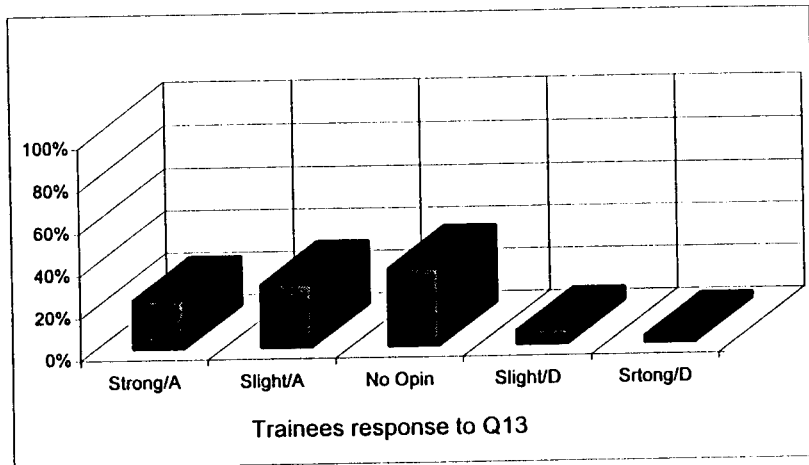


## Trainees response to each question

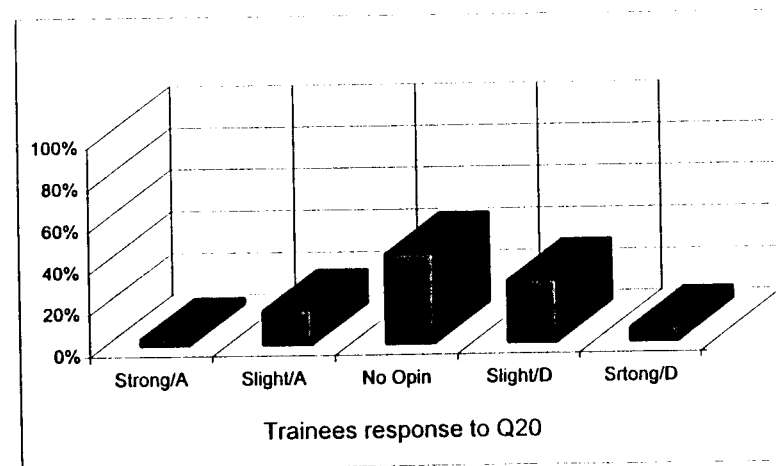
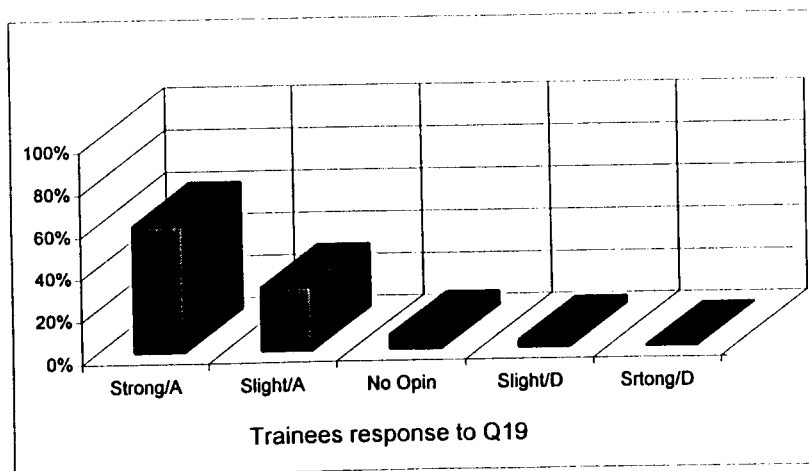
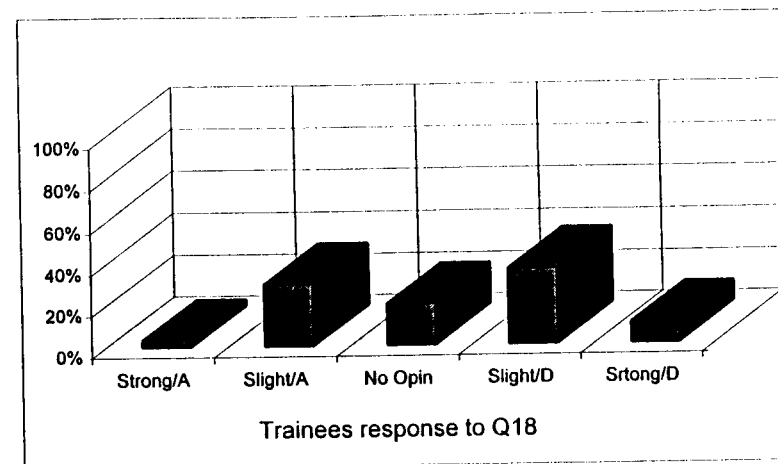
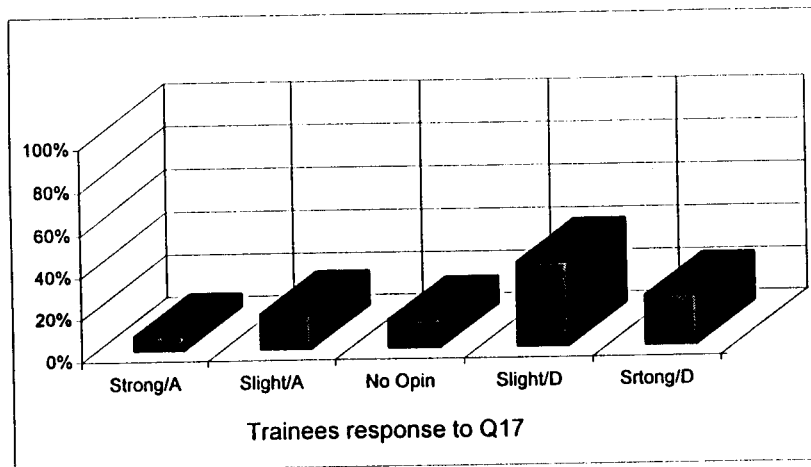


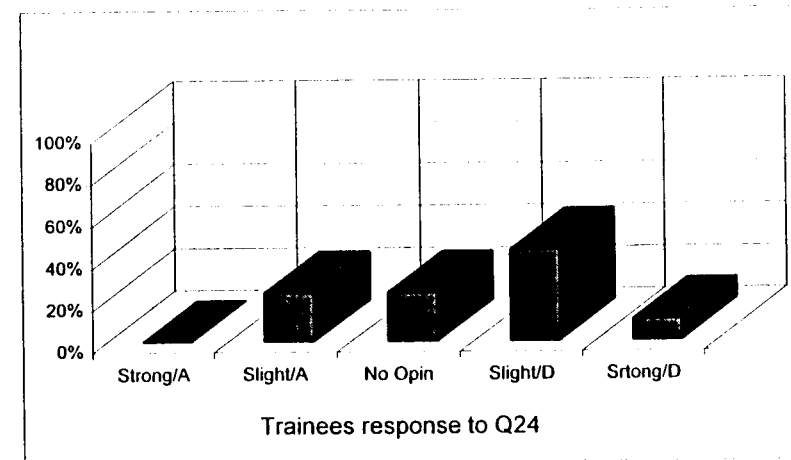
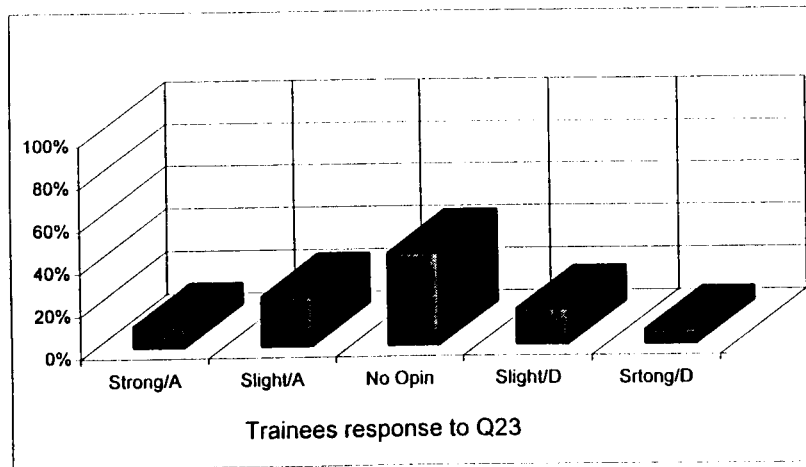
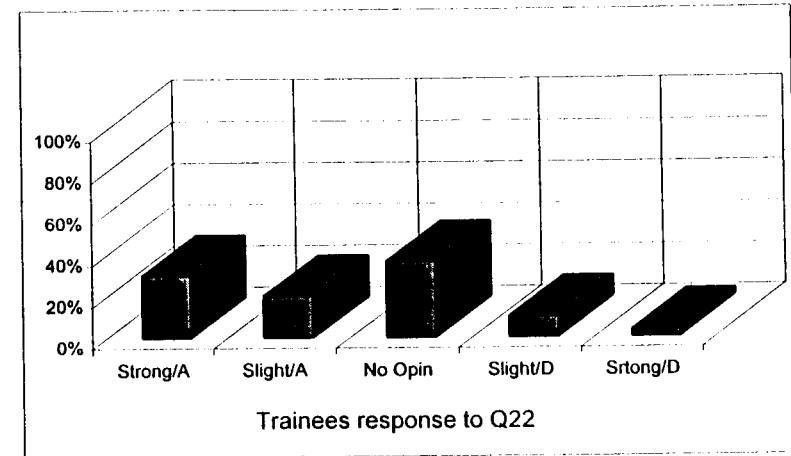
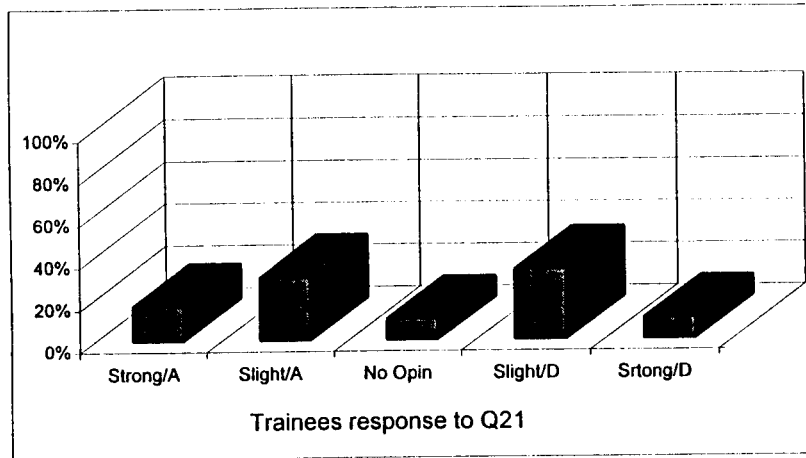


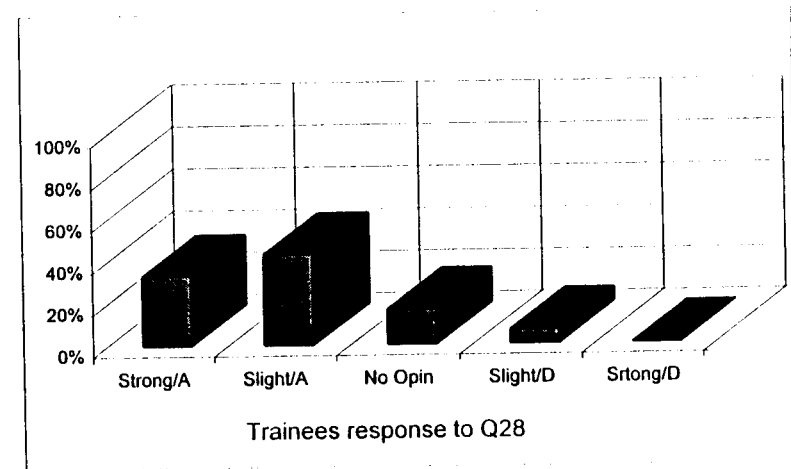
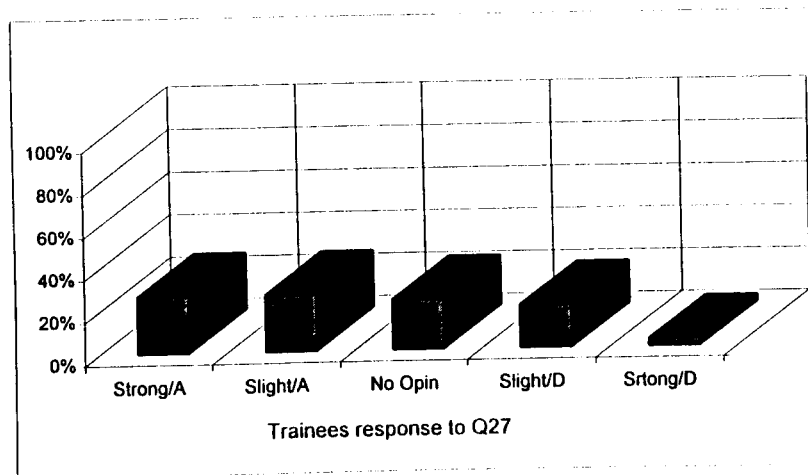
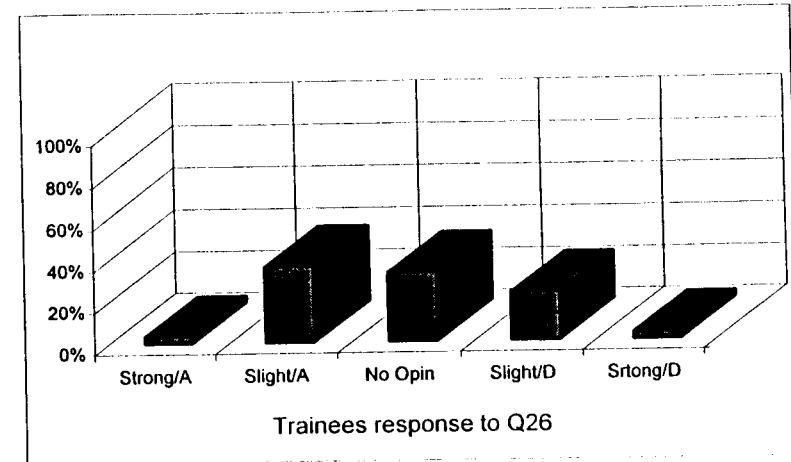
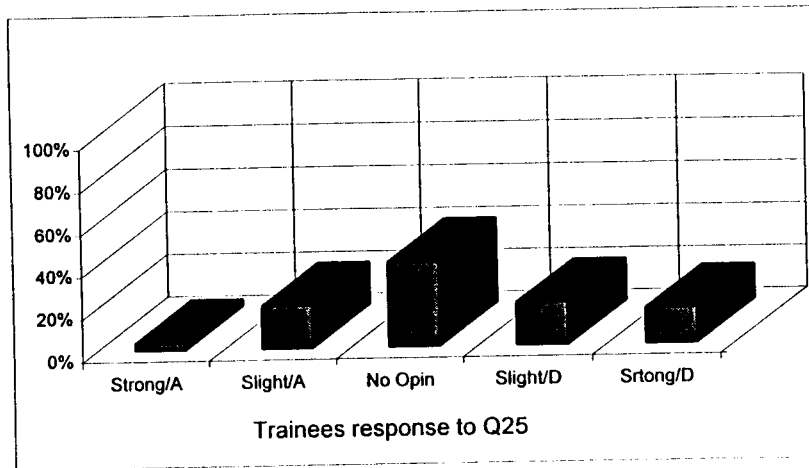


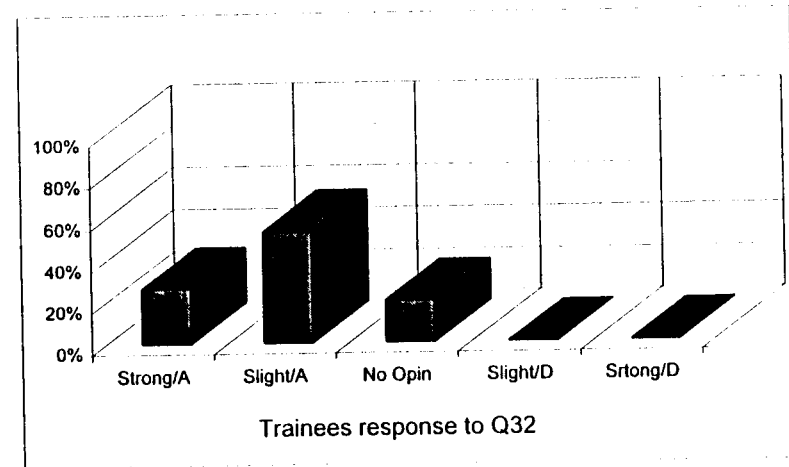
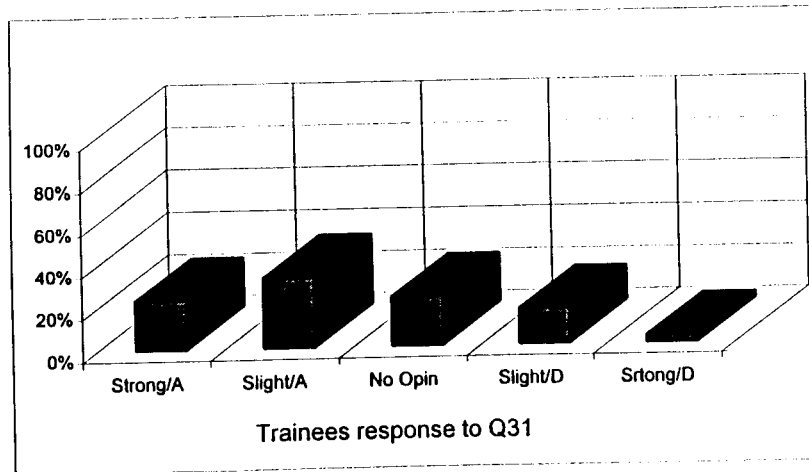
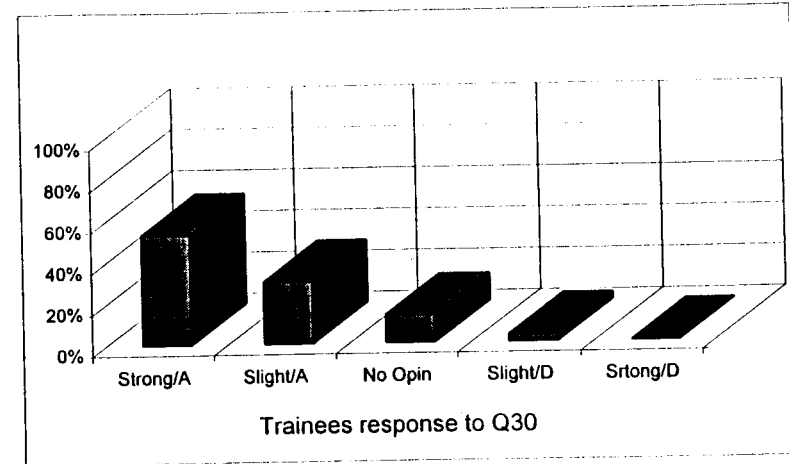
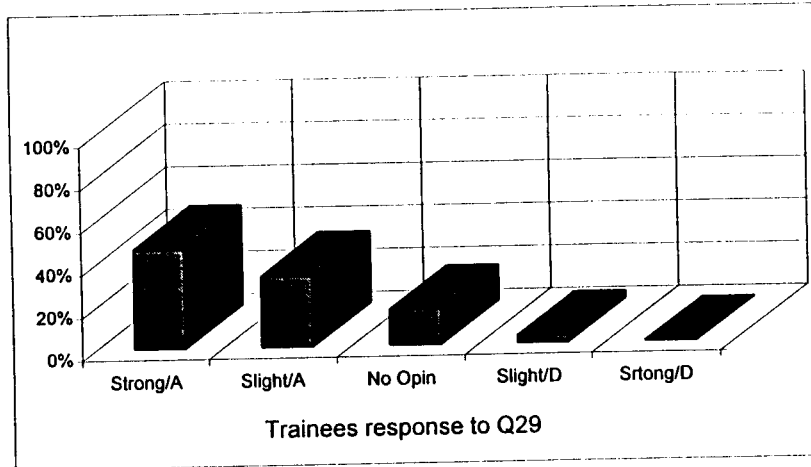


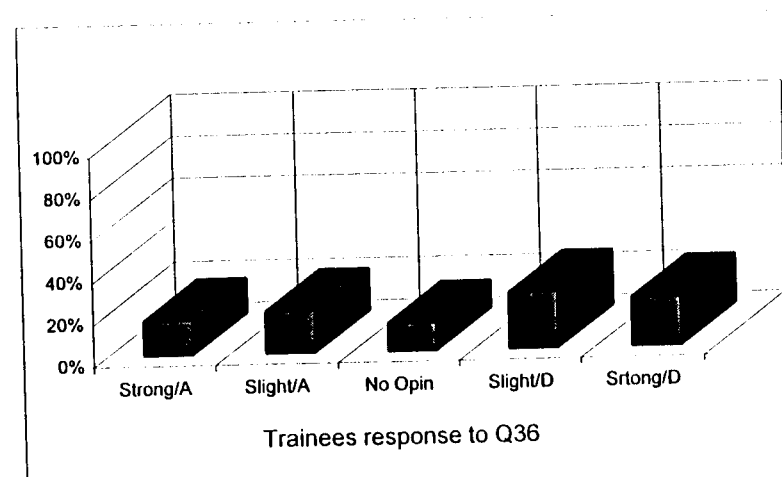
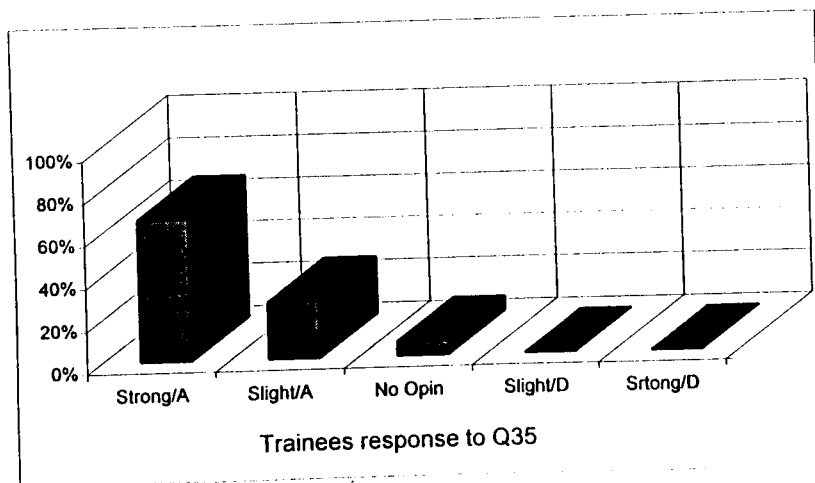
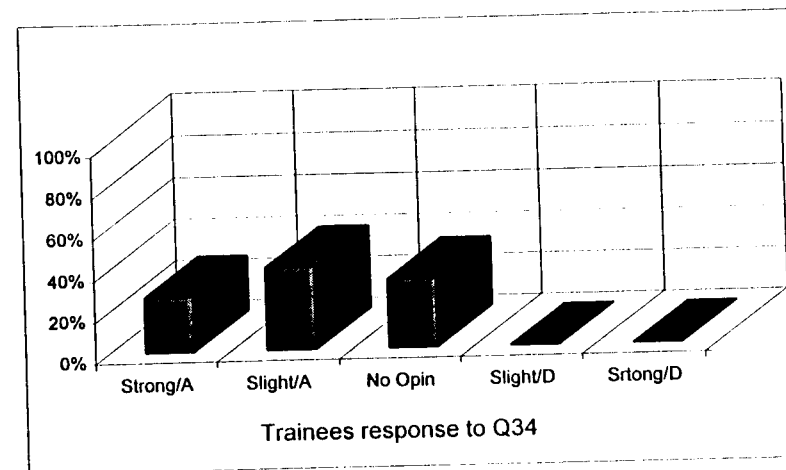
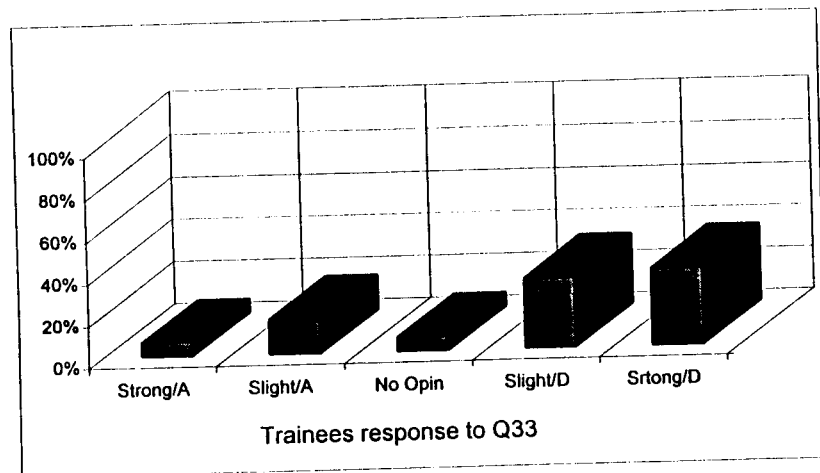


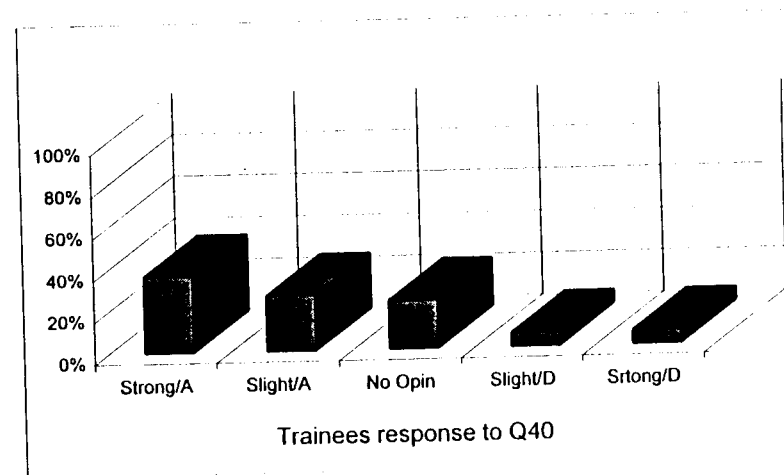
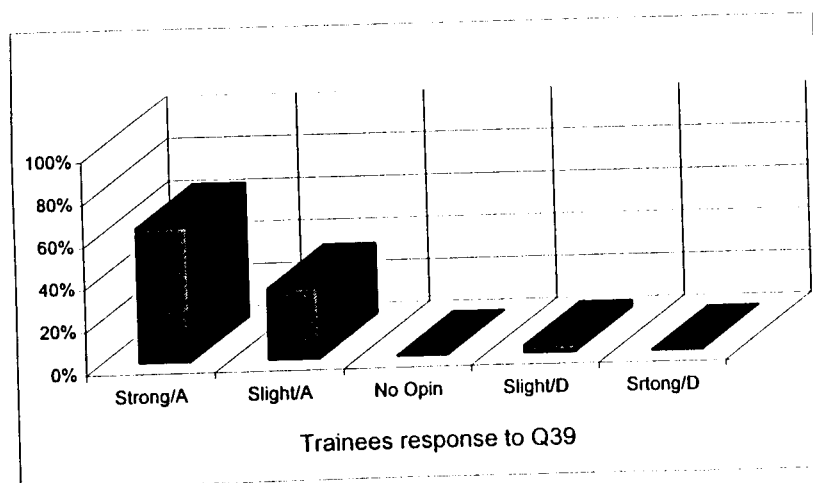
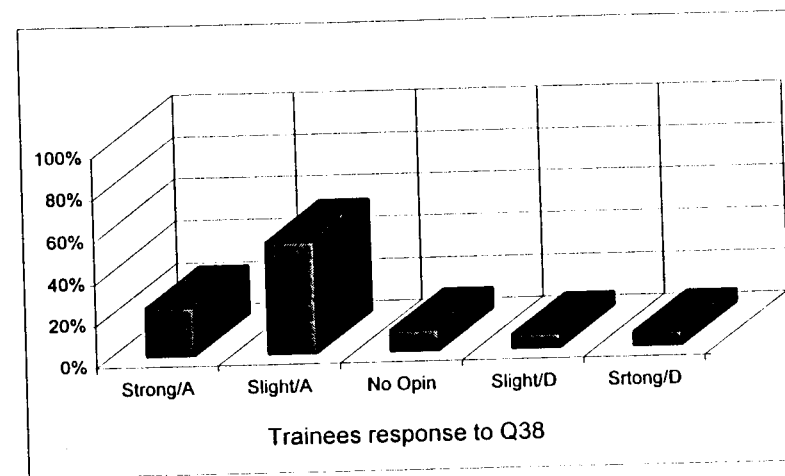
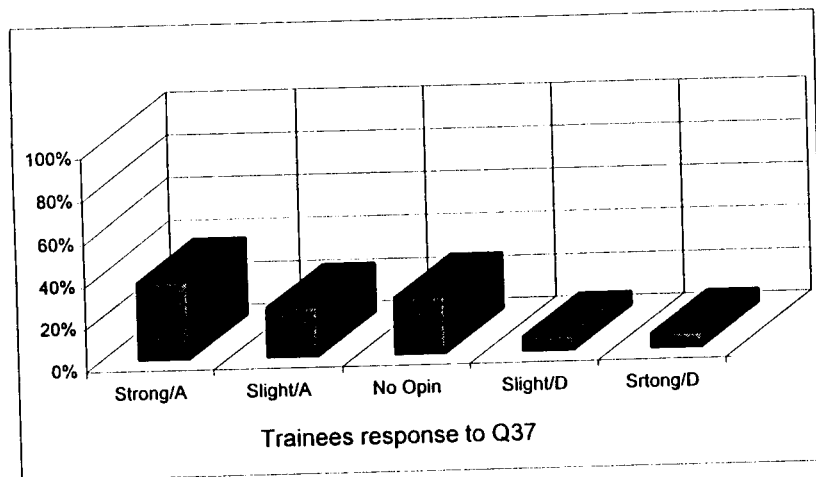












# **Appendix G**

Civil engineering management questionnaire

**DEPARTMENT of CIVIL ENGINEERING**  
**and BUILDING SCIENCE**

**CIVIL ENGINEERING MANAGEMENT QUESTIONNAIRE**

Please tick the **boxes** provided and where appropriate please tick **as many** options **as** required.

1. What is your age?

- Under 25 ☐
- 26-30 ☐
- 31-35 ☐
- 36-40 ☐
- 41-45 ☐
- 46-50 ☐
- 51-55 ☐
- 56+ ☐

2. *Are* you:-

- Male ☐
- Female ☐



3. What is your position in the company?

Chairman ☐  
Managing Director ☐  
Partner ☐  
Other [Please specify] ☐

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4. **How** many years have you spent in the Construction or Civil Engineering field?

0-5 ☐  
6-10 ☐  
11-15 ☐  
16-20 ☐  
21-25 ☐  
26-30 ☐  
31+ ☐

5. **How** many years have you been with this company?

0-5 ☐  
6-10 ☐  
11-15 ☐  
16-20 ☐  
21-25 ☐  
26-30 ☐  
31+ ☐

6. What are your professional qualifications? Please mark as many as appropriate.

B.Sc. ☐  
B.Eng. ☐  
C.Eng. ☐  
M.Sc. ☐  
Ph.D. ☐  
M.I.C.E. ☐

7. In what parts of the world have you worked and for how long?

Please mark as many as appropriate.

U.K.	<input type="checkbox"/>	Years —	Months —
Western Europe	<input type="checkbox"/>	Years —	Months —
Eastern Europe	<input type="checkbox"/>	Years —	Months —
Africa	<input type="checkbox"/>	Years —	Months —
Northern America	<input type="checkbox"/>	Years —	Months —
Southern America	<input type="checkbox"/>	Years —	Months —
Middle East	<input type="checkbox"/>	Years —	Months —
Far East	<input type="checkbox"/>	Years —	Months —
Australia & New Zealand	<input type="checkbox"/>	Years —	Months —
Others [Please Specify]			

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8. Today many companies ~~run~~ management training schemes. Have you ever participated in such a management training scheme?

Yes ☐

No ☐

9. ~~Does~~ your *firm* use management training schemes?

Yes ☐

No ☐

9a. If your firm does use management training schemes are they organised by your ~~firm~~ or by another company?

By us ☐

By another company [Please specify which company] ☐

---

10. Does your **firm** either run or use a Quality Assurance scheme? Yes ☐  
No ☐

**10a. If your ~~firm~~ does run a Quality Assurance scheme is it an in house scheme or is it organised by a Q.A. company?**

In house scheme ☐  
QA company [Please specify which QA company] ☐  
\_\_\_\_\_

11. Do you have a computer at home? Yes ☐  
No ☐

**11a. If you do have a computer at home who would you say uses it most?**

I use it most ☐  
My husband/wife ☐  
My children ☐  
It is used by every one in the house equally ☐  
It is hardly used at all ☐

- 12. How useful do you feel computer technology is for engineering purposes?**  
I feel it is:-

essential ☐  
very useful ☐  
useful ☐  
not very useful ☐  
useless ☐

13. How useful **do** you feel computer technology **is** for management purposes?

I feel it **is**:-

- essential ☐
- very useful ☐
- useful ☐
- not very useful ☐
- useless ☐

14. How comfortable **do** you feel **about using** a computer?

- Very comfortable ☐
- Comfortable ☐
- Indifferent ☐
- uncomfortable ☐
- Very uncomfortable ☐

15. Does your company have **a** computer system?

- Yes ☐
- No ☐

**IF YOUR COMPANY ~~WES~~ NOT HAVE A COMPUTER SYSTEM  
IT IS NOT NECESSARY TO ANSWER ANY FURTHER QUESTIONS**

16. What **type** of computer system is it?

- Mainframe ☐
- Miniframe ☐
- Workstations ☐
- Networked PC's ☐
- Individual PC's ☐

17. How long ago was the computer system introduced?

- Under 2 years ☐  
3-4 years ☐  
5-6 years ☐  
Over 7 year ☐

18. What is it used for? [Please **mark** as many as appropriate]

- Estimating/Tendering ☐  
Planning ☐  
Finance [Accounts] ☐  
Administration and wages ☐  
Secretarial ☐  
Design ☐  
Data Storage ☐  
Quantity Surveying ☐  
Marketing ☐  
Others [Please specify] ☐
- 
- 

19. Was a feasibility study carried out prior to **the** system being introduced?

- Yes ☐  
No ☐

20. How **would you** say the system is the performing **in** relation to what was expected from it?

- Better than expected ☐  
In line with expectations ☐  
Not as well as expected ☐

21. Did the actual cost of the system match the estimated cost of the system?

The system was more expensive than estimated ☐  
Cost matched the estimate ☐  
Cost less than estimated ☐

22. How long did the installation and introduction of the system take?

Either Years \_\_\_\_\_ Months \_\_\_\_\_  
Or man years \_\_\_\_\_

23. How long was it before benefits were gained from having the system?

Years \_\_\_\_\_ Months \_\_\_\_\_

24. Have there been noticeable improvements in the areas designed to benefit from the computer system?

Yes ☐  
No ☐

25. Is the software that is used on the computer purchased from an external source or is it designed by your company?

The software is purchased from an external source ☐  
The software is designed by us ☐

26. Is special training needed to use the software?

Yes ☐  
No ☐

27. Is training provided to use the system?

Yes ☐  
No ☐

28. What percentage of your time would you say you spent using your computer at work?

- Less than 20% ☐  
20-40% ☐  
40-60% ☐  
60-75% ☐  
75%+ ☐

29. Which of the following aspects of a manager's work has the computer system aided?

- Technical aspects ☐  
Organisational aspects ☐  
Long term planning ☐

30. Has the computer system ever resulted in any re-organisation of the company structure either directly or indirectly?

- Yes ☐  
No ☐

30a. If you answered yes to the above question please mark which of the following areas were reorganised

- Senior Management ☐  
Middle Management ☐  
Site activities ☐  
Design office ☐  
Administration ☐  
Secretarial ☐  
Others [Please specify]

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Neil Scott, David Ponniah & Ben Saud, Computing and the Construction Industry; Structural Survey - Vol.12 No.4 (1993/4) pp.10-14.